Water Resource Inventory and Assessment Port Louisa NWR November 2013

November 2013

Cover Image: Port Louisa National Wildlife Refuge Divisions overlain with USGS topography maps and (inset) National Hydrologic Dataset indicating major river basins

The mission of the U.S. Fish & Wildlife Service is working with others to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

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1 Executive Summary

The Water Resource Inventory and Assessment (WRIA) is a reconnaissance-level effort, which is an inventory and assessment of water rights, water quantity, water quality, water management, climate, and other water resource issues. The WRIA summary narrative supplements existing and scheduled planning documents, by describing current hydrologic related information and providing an assessment of water resource needs and issues of concern.

Port Louisa National Wildlife Refuge (PLNWR) is located in Iowa and Illinois adjacent to the Mississippi and Iowa Rivers. PLNWR has four divisions, which are Big Timber, Louisa, Horseshoe Bend, Keithsburg and the Iowa River Corridor Project (IRCP) area. Conservation goals and objectives for the Port Louisa divisions (excluding IRCP) are identified and discussed within the Mark Twain National Wildlife Refuge Complex Comprehensive Conservation Plan (CCP; USFWS 2004). Specific habitat objectives, management regimes and site monitoring will be within a Habitat Management Plan (HMP) and Inventory & Monitoring Plan (IMP).

The Contaminants Assessment Process (CAP) is complete for the Refuge (Coffey et al. 2012). Many of the findings and recommendations within the CAP are applicable to water resources and are reiterated here in the WRIA summary narrative.

A WRIA was completed separately for the IRCP, which is a geographically isolated area of Port Louisa NWR, with minimal active management of water (Newman 2012; ServCat reference 15606). The Iowa DNR manages the USFWS IRCP, based on a memorandum of understanding and a comprehensive management plan.

1.1 Findings

In general, water resource related concerns for the Refuge are flooding, sedimentation, erosion control and water quality (fecal coliform, nitrogen, phosphorus, etc.). The impacts of these issues on Refuge resources are usually a function of topography, agricultural practices and development in the region, relative to surface and ground waters.

1) In 2009, participants in a hydrogeomorphic evaluation workshop discussed the historical conditions at the Keithsburg Division and identified the most salient management concerns, based on current conditions. The primary hydrologic concern was the frequency and length of flooding and inability to manage water levels.

2) The Refuge Divisions water supplies are heavily influenced by direct runoff from agricultural fields and over-bank flooding from the Mississippi River, the Iowa River, the Pope River and Edwards River at a variety of flood-frequency return intervals.

3) Current precipitation and runoff data from the last century suggests that there have been long-term increases in precipitation and river runoff in this part of Iowa (Hayhoe 2010). The Mississippi River is anticipated to have an increasing frequency of flood events (Zhang and Shilling 2006, Easterling and Karl 2008). Studies predict earlier spring runoff with higher peak flows from the larger snow-driven rivers in the area, but large variability in runoff from smaller rivers. Increasing precipitation is counter-balanced by an increasing average temperature, particularly during the summer (day and night). Greater mean temperature may lead to reductions in soil moisture through evaporation and increased evapotranspiration by plants, leading to comparatively less runoff from precipitation events and quicker development of drought conditions.

4) Historical temperature data suggests that the average daily-minimum temperature (typically at night) has increased approximately 2 degrees over the last 60 years near the Refuge. Daytime temperature data did not indicate an apparent trend.

5) It is possible that there is reduced connectivity at low-flow events due to sedimentation at the inlet for the Big Timber Division. Yearly sedimentation rates in the Big Timber Division were underestimated within the design plan for the U.S. Army Corp of Engineer (USACE) Habitat Restoration & Enhancement Project (HREP), which dredged sediments to enhance deep-water habitats (1989-1994). Approximately 20 years post-construction, it is extremely likely (but not confirmed) that the 50-year mean depth and target volumes for deep-water habitat are no longer being met, based on information in the year 15 evaluation report (USACE 2007). The continued reduction in deep-water habitat and connectivity will likely impact fisheries in the Division.

6) An evaluation of the Iowa River near Wapello, IA gage data from 1958-2012 suggest that typically high flow pulses (>75% of daily flows for the period) are not happening as often, but have a longer duration when they occur. The rising limb of river discharge for these larger flood events is happening faster (i.e. +cfs/day) and falling slower. Over the period of record, monthly median flows have increased, particularly in May and June.

7) The WRIA identified 59 elements of water control infrastructure (excluding levees), which control water inundation elevation either actively or passively. These include 28 boardstop, 10 screw-gate, 14 culverts, 3 pump stations and 4 spillways. Spillways were only counted if they included armoring typical of these types of structures.

8) There are no impaired water listings or fish consumption advisories within the Refuge units under Section 303(d) of the Clean Water Act. However, small tributaries or ditches have not necessarily been assessed. There are three impaired water listings for waters adjacent to some of the Refuge units. The Mississippi River adjacent to Big Timber Division and Louisa Division does not support aquatic life usage or drinking usage due to elevated levels of arsenic, aluminum and cadmium. The area adjacent to Keithsburg Division, below the Iowa River confluence does not fully support fish consumption, due to mercury and PCB concentrations in fish tissues. A portion of the lower reach of the Edwards River does not support primary contact use due to elevated fecal coliform bacteria counts.

9) Water quality information is available for a number of resources, particularly for the Mississippi River, the Iowa River and Edwards River, which have comprehensive sampling completed by the USGS, EPA, IL EPA and IA DNR.

10) The National Wetland Inventory (NWI) was completed for Iowa in 2002 and in 1984 for Illinois. The percentage of land classified as wetlands within the acquired units ranged from 31% (Horseshoe Bend) to 99% (Big Timber). The "lake" designation typically represented the highest percentage for the Divisions, except at Horseshoe Bend (7%), which is primarily shrub/scrub wetland. Based on the NWI, typical wetlands on the Divisions are forested, emergent and shrub wetlands. Forested wetlands typically were further characterized as broad-leaf deciduous wetlands.

11) NHD flowlines were clipped to a ¼-mile buffer of the Refuges acquisition boundary and summarized based on named features and feature types (i.e. USGS FCodes). Approximately 77.6 miles of NHD flowpaths were identified in the Big Timber, Louisa, Horseshoe Bend, and Keithsburg Divisions, 27.29 miles (35.17%) of which are named features. The flowpaths can be broken down based on type: 3.92 miles (5.05%) perennial streams and rivers, 21.3 miles (27.45%) as intermittent streams and rivers, and 52.11 miles (67.15%) as canals, ditches, or artificial paths.

1.2 Recommendations

1) The CAP (Coffey 2012) recommended water quality testing to determine nutrient loads along the pathways as a means to rank and prioritize the sources. These rankings will help guide resource management actions to divert or treat excessive loads of nutrients and activities by partners in the watersheds to reduce nutrient use or loss. Seasonal and event based sampling would be most effective at Horseshoe Bend and Keithsburg, which receive water from a number of small ditches. The installation of small buffer wetlands and bioreactor materials within flowpaths could lead to a significant reduction in chemicals of concern to priority water resources.

2) Complete a bathymetric survey of the Big Timber Division inlet and backwater areas to determine the current condition and monitor change. This data will help determine if dredging or excavating these areas is warranted. Contact the USACE to discuss the likelihood that the HREP is currently not on track to meet 50-year targets for minimal fisheries habitat diversity. Install a temporary levee to drain the backwater area during a low-water period could provide improvements to habitat and enable mapping and excavation.

3) A visit by a U.S. Fish and Wildlife hydrologist found anoxic conditions in the Big Timber Division backwater area, which may be detrimental to fish and other wildlife. Low dissolved oxygen is an issue of concern and should be evaluated. Increased depth and more flow-through may improve this situation, which is likely a common occurrence. Collection of regular water profiles (day and night) would help to determine if this is problematic and if this area would necessitate an impaired designation.

4) Utilize LiDAR information to evaluate topographical aspects (i.e. slope, aspect, flood inundation) in combination with soil and vegetation data to create land suitability typology. Leverage availability of GIS watershed data to assess watershed level areas for erosion and identification of possible best management practices locations. These activities are currently in process for the Horseshoe Bend Division.

5) Ditch maintenance should be evaluated to consider the feasibility of a two-tier design. This type of design will improve conveyance during low flow through reduced cross-sectional area, and increase the areas exposed to flooding during high flows.

6) Enhance connectivity of the Keithsburg Division to the Edwards River or the Mississippi River to create more of a flow-through system. The Keithsburg Division should be further evaluated based on the likelihood and length of inundation from the Mississippi River.

7) Water quality sampling, sediment sampling and biological sampling should focus on arsenic, aluminum, cadmium and E. coli, since these are the typical contaminants of concern identified in the Mississippi and Iowa Rivers.

8) Evaluate the possibility of alternative water supplies to maintain water levels during droughts. Drying cycles in wetlands and moist soil units are often ecologically beneficial. However, as drought and heavy precipitation events become more common, it may be increasingly important to impound water earlier in the summer and/or pump water from groundwater sources.

2 Introduction

This WRIA summary report for PLNWR describes current hydrologic information, provides an assessment of water resource needs and issues of concern, and makes recommendations regarding Refuge water resources. This Summary Report synthesizes and compiles water resource data contained in the national interactive online WRIA database. The information contained within this report and supporting documents will be entered into a national database for storage, online access, and consistency with future WRIAs. The database will facilitate the evaluation of water resources between regions and nationally. This report and the database are intended to be a reference for ongoing water resource management and strategy development.

The WRIA is a reconnaissance-level effort that will inventory and assess water rights, water quantity, water quality, water management, climate, and other water resource issues for each Refuge. The long-term goal of the National Wildlife Refuge System (NWRS) WRIA effort is to provide up-to-date, accurate data on Refuge System water quantity and quality in order to acquire, manage, and protect adequate supplies of water. Achieving a greater understanding of existing information related to refuge water resources will help identify potential threats to those resources and provide a basis for recommendations to field and Regional Office staff. Through an examination of previous patterns of temperature and precipitation, and an evaluation of forward-looking climate models, the U.S. Fish and Wildlife Service (USFWS) aims to address the effects of global climate change and the potential implications for habitat and wildlife management goals on a specific Refuge.

Water Resources Inventory and Assessments are an important part of NWRS Inventory and Monitoring (I&M), and were identified as a need by the *Strategic Plan for Inventories and Monitoring on National Wildlife Refuges: Adapting to Environmental Change* (USFWS 2010a, b). Inventory and monitoring is one element of the USFWS's climate change strategic plan to address the potential changes and challenges associated with conserving fish, wildlife and their habitats (USFWS 2011). A national team of USFWS water resource professionals, environmental contaminants Biologists, and other Service employees has developed WRIAs.

The WRIA will be a useful tool for Refuge management and future assessments, such as a hydro-geomorphic analysis (HGM), and can be utilized as a planning tool for the CCP, HMP and IMP.

Water resources staff in the Division of Biological Resources (NWRS) conducted a site visit, interviewed Refuge staff and received comments from Cathy Henry (USFWS) and Jessica Bolser (USFWS).

3 Facility Information

Formerly, the PLNWR Divisions were managed as part of Mark Twain National Wildlife Refuge Complex. In 2000, Mark Twain NWR split into five separate refuges, and the Divisions within the Wapello District of Mark Twain NWR became PLNWR. A comprehensive history of the establishment of the Refuge facility is available within the CCP (ServCat Reference 1554).

The five divisions of PLNWR, Big Timber, Louisa, Horseshoe Bend, Keithsburg and the IRCP, encompass approximately 18,000 acres (Figure 1). The Divisions are located within the Upper Mississippi Alluvial Plain Level 4 Ecoregion (72d; Omernik 1987, 2004) and the Eastern Tallgrass Prairie & Big Rivers Landscape Conservation Cooperative (LCC). The Upper Mississippi Alluvial Plain includes the floodplains and low terraces of the Mississippi River above the confluence with the Missouri River. Before the 19th century, this area contained bottomland forests adapted to flooding, mesic and wet prairies on bottomlands and dry prairies located in sandy well-drained areas. The Divisions within the Refuge(s) are part of a highly altered hydrologic system, where water levels and management activities are influenced by Mississippi River water level elevation and infrastructure. Water management activities strive to mimic the timing, magnitude and frequency of pre-settlement water inundation and extent. Additionally, water management aims to maximize the variety and quality of habitat for target species based on seasonal patterns and ideal water level management regimes (i.e. temporary, seasonal, and semi-permanent) for the management units.

Hydrologic Unit Codes (HUC) are used to designate watersheds of various sizes and often represent the initial aggregate level of water quality and quantity information available from a variety of agencies (e.g. EPA Surf your watershed, Link; Figure 2). HUC boundaries are a successively smaller classification system based on drainage, adapted from Seaber et al. (1987). The 10-digit HUC (HUC-10) boundary is the potential zone of hydrologic influence and a relevant region for the collection of water quality and quantity information for the WRIA. HUC-10s were used as a basis for collecting existing data on water chemistry, water quantity and climate (Figure 2). The smaller HUC-12 boundaries are also evaluated herein, if they contained the primary Refuge source waters.

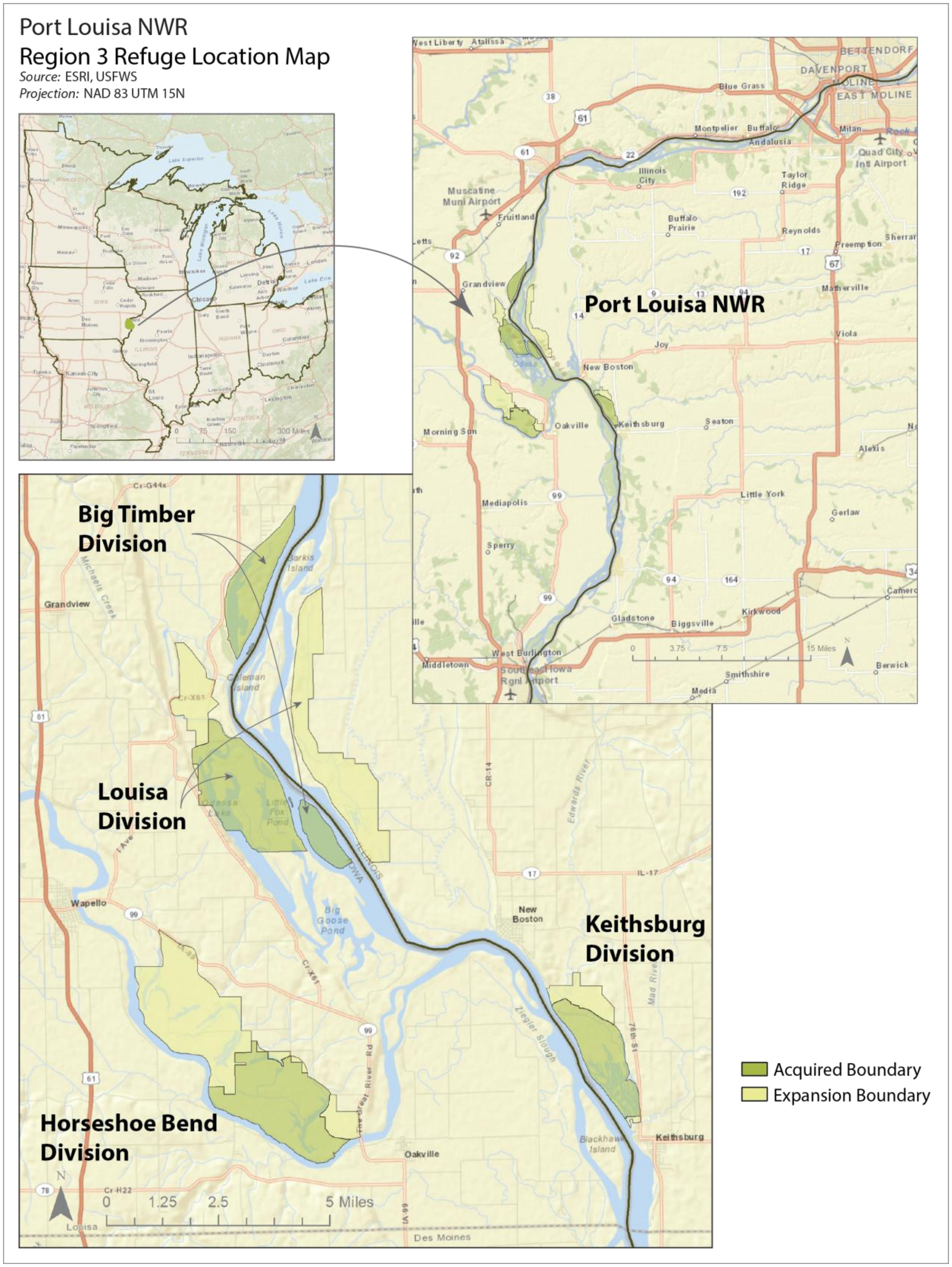
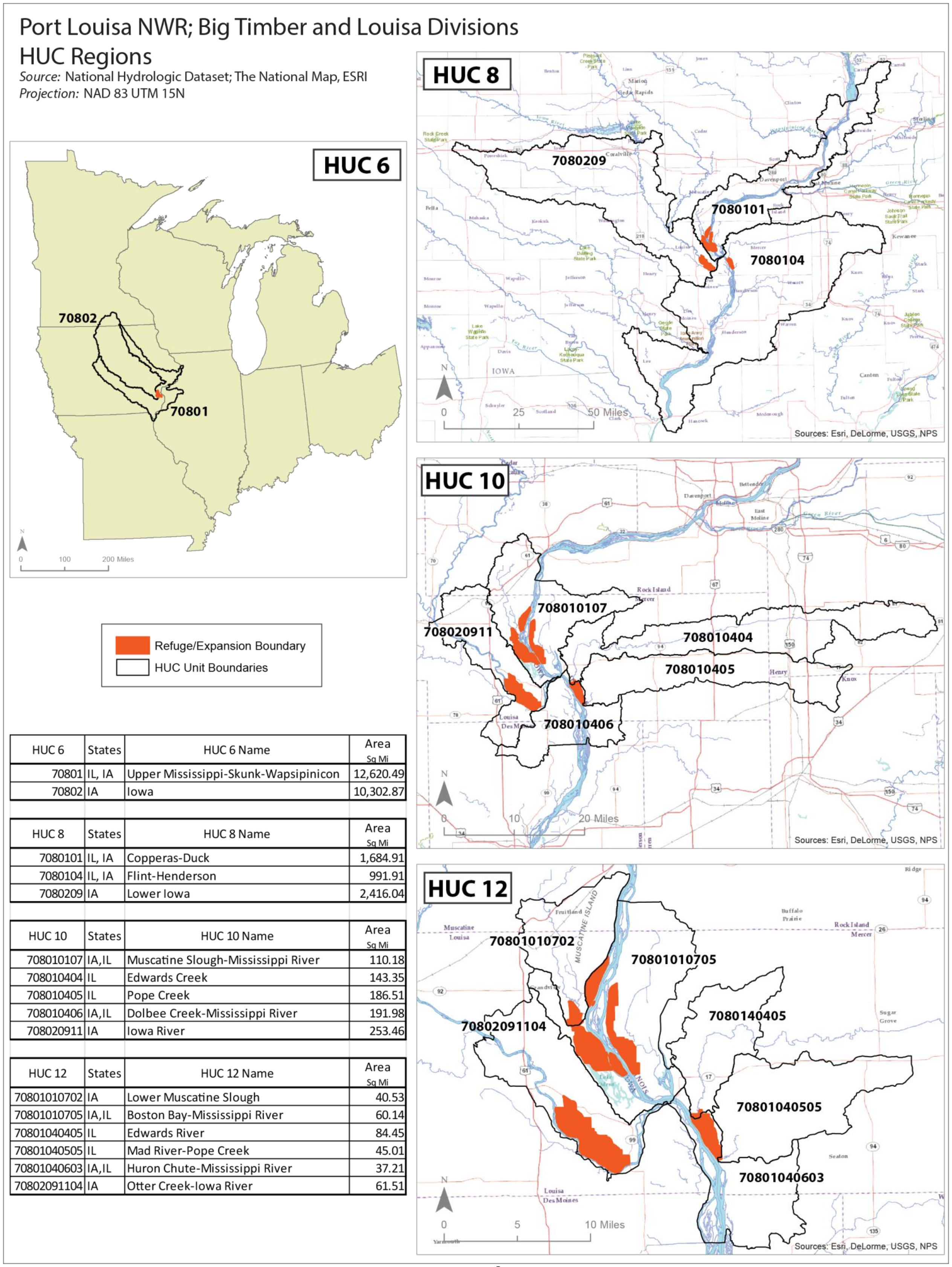


Figure 1 Refuge Division boundaries and locations



HUC 6	States	HUC 6 Name	Area Sq Mi
70801	IL, IA	Upper Mississippi-Skunk-Wapsipinicon	12,620.49
70802	IA	Iowa	10,302.87

HUC 8	States	HUC 8 Name	Area Sq Mi
7080101	IL, IA	Copperas-Duck	1,684.91
7080104	IL, IA	Flint-Henderson	991.91
7080209	IA	Lower Iowa	2,416.04

HUC 10	States	HUC 10 Name	Area Sq Mi
708010107	IA,IL	Muscatine Slough-Mississippi River	110.18
708010404	IL	Edwards Creek	143.35
708010405	IL	Pope Creek	186.51
708010406	IA,IL	Dolbee Creek-Mississippi River	191.98
708020911	IA	Iowa River	253.46

HUC 12	States	HUC 12 Name	Area Sq Mi
70801010702	IA	Lower Muscatine Slough	40.53
70801010705	IA,IL	Boston Bay-Mississippi River	60.14
70801040405	IL	Edwards River	84.45
70801040505	IL	Mad River-Pope Creek	45.01
70801040603	IA,IL	Huron Chute-Mississippi River	37.21
70802091104	IA	Otter Creek-Iowa River	61.51

Figure 2 Hydrologic Unit Code (HUC) boundaries and area (mi^2) for Port Louisa National Wildlife Refuge (PLNWR)

3.1 Big Timber

The Big Timber Division (Figure 3) includes a main land section and four islands located in Louisa County, Iowa at Mississippi river miles 445 to 438 (miles upstream of Mississippi River and Ohio River confluence). The Division is in Pool 17, approximately 10-12 miles south of Muscatine, IA. The Division is also within the Muscatine Slough-Mississippi HUC-10 (0708010107) and within the smaller Boston Bay-Mississippi River HUC-12 (070801010705).

The Division is primarily managed as a flood-plain forest. In 1994, the Division's sloughs and side channels were dredged and excavated as part of a USACE Habitat Rehabilitation and Enhancement Project (HREP; Link).This project consisted primarily of hydraulic dredging, and mechanical excavation to enhance deep-water (> 6'), shallow-water (>2' and <3') habitat and ensure that connections to the backwater area were maintained. The project was designed with a 50-year timeline of maintaining target depths and cross-sectional areas. However, sedimentation rates are approximately 3 times the original design plan estimate and the most recent transects available (2002) indicated that the areas of deep-water habitat had decreased from an average depth of 6.5' to 4.9' with a water volume reduction of 67.2 acre-feet to 49.9 acre-feet over an 11 year period (USACOE 2007). It is extremely likely that siltation in the Division has affected emergent vegetation and fisheries. It is likely that the HREP design will not meet the 50-year target of 42.4 acre-feet, with an average depth of 6 ft. on the Division.

Water levels are controlled roughly 75% to 85% of the year by Lock & Dam 17, located at river mile 437. The remaining 25% to 15% of the year, stream-flow on the Mississippi exceeds the ability of the Lock & Dam to maintain water levels. Typically, the water elevation in Pool 17 is managed at 535.5-536 feet above mean sea level (MSL 1912). When stream-flow exceeds Lock & Dam 17 control (e.g. flood stage), water levels at the Division will typically be 0.5 to 0.75 ft. higher per mile upstream of the USACE Pool 17 gauge readings. In 1875, the main land portion of the Big Timber Division had river access at the north end, essentially making more of a flow-through system. In addition, the forest was far less predominant, possibly because timber harvesting was common in this area.

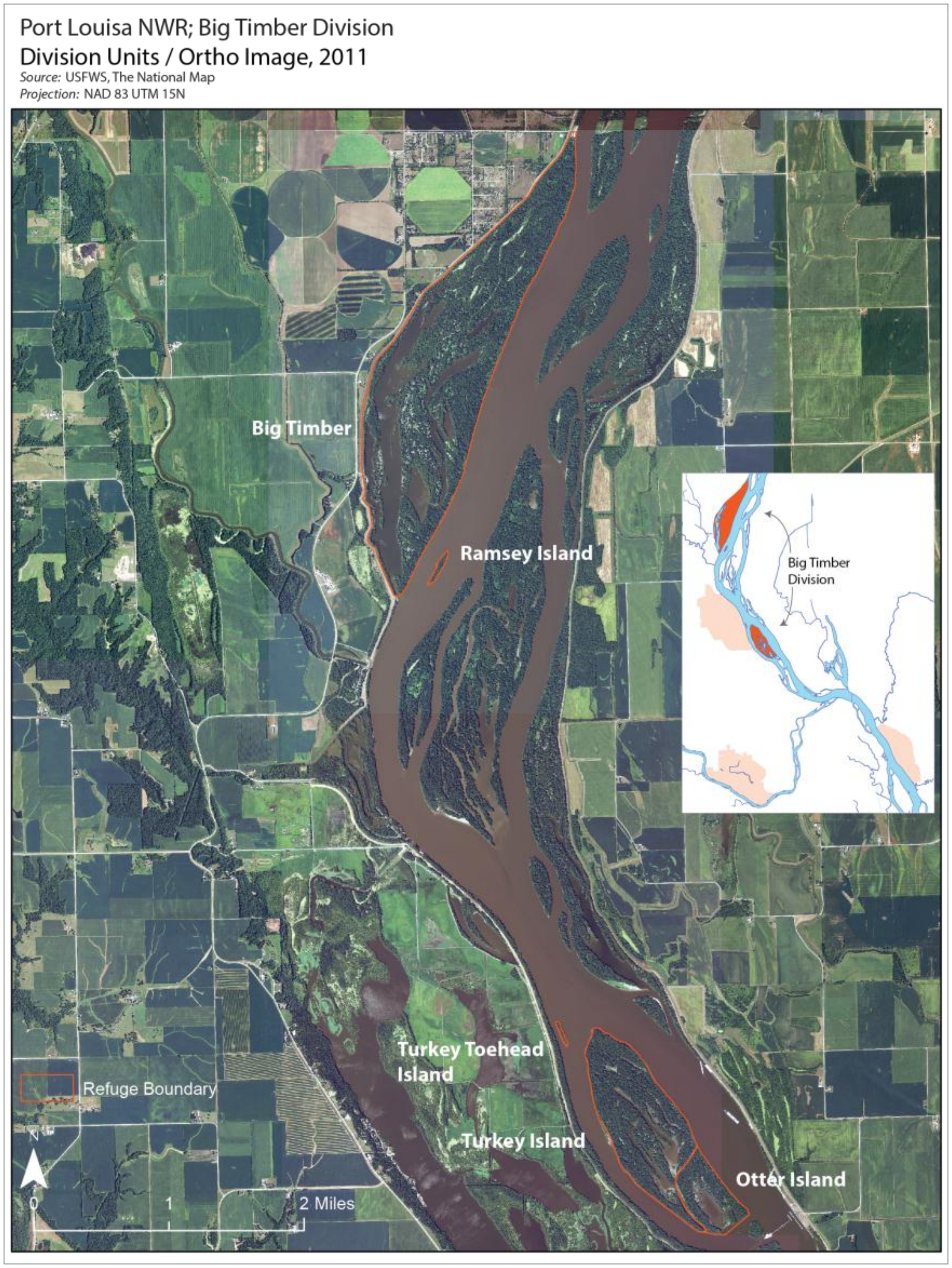


Figure 3 Big Timber Division boundary and 2011 aerial image

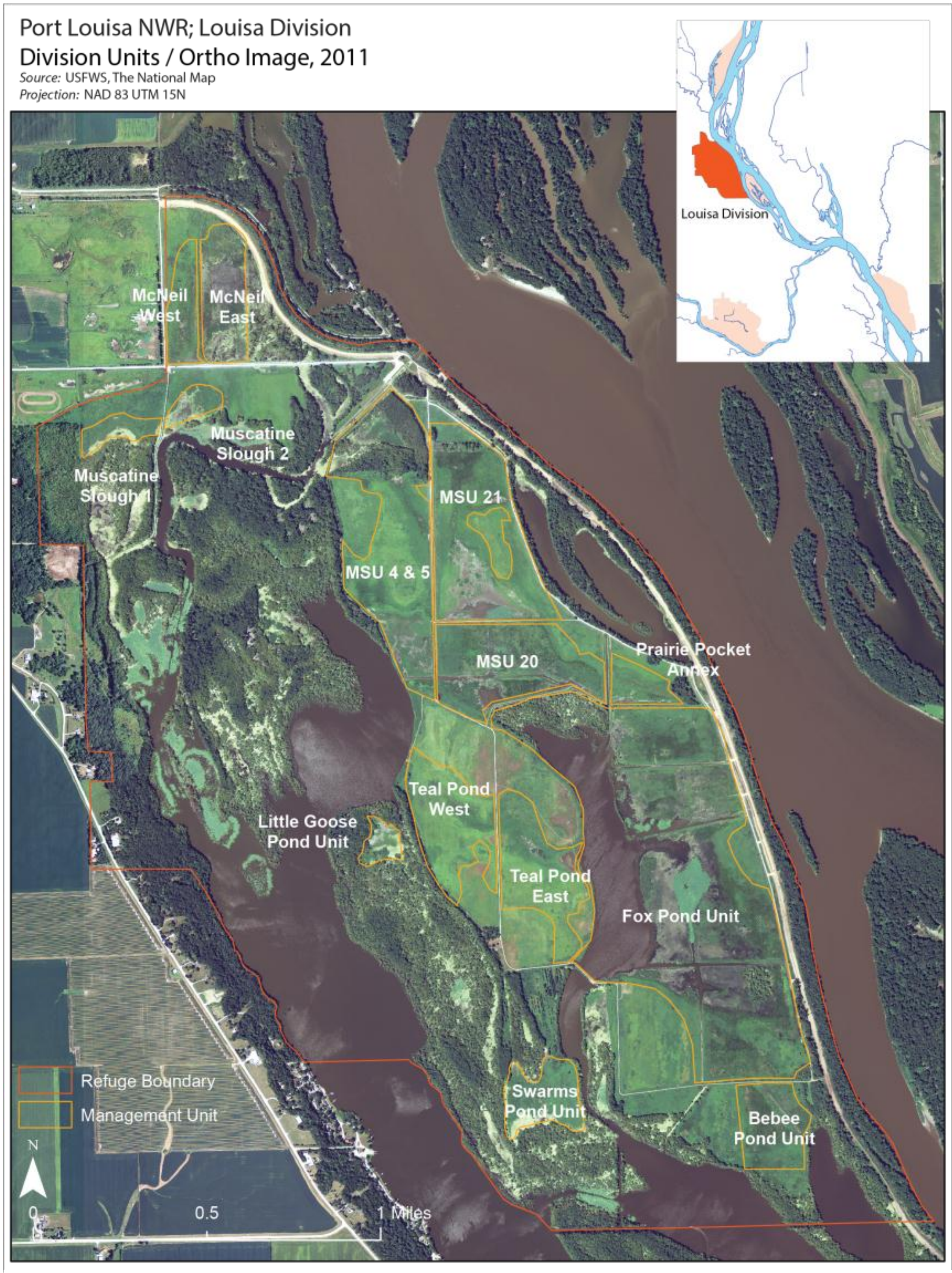


Figure 4 Louisa Division boundary and 2011 aerial image

3.2 Louisa

This Louisa Division is located in Louisa County, IA, east of Wapello, Iowa (Figure 4 and Appendix A Historical map of Louisa County). The Division extends from approximately river mile 441.5 to 438, adjacent to Pool 17 on the Mississippi River. It is located within the Muscatine Slough-Mississippi HUC-10 (0708010107) and within the smaller Boston Bay-Mississippi River HUC-12 (070801010705).

The habitats of this Division are primarily managed as marsh riverine/moist soil units, floodplain forests and wet bottomland prairie. In addition to water level manipulation, the wetland management units are disked, burned and mowed to maintain a diversity of plants, which provide forage for migratory shorebirds, marsh birds and waterfowl.

The Division can receive Mississippi River water through a water control structure (WCS) located on the northeast side of the Refuge facility or through over-bank flooding from the Mississippi River. Water level elevation in Lake Odessa is cooperatively managed with the Iowa Department of Natural Resources, which maintains and manages the outlet structure for Odessa Wildlife Management Area. Historically, Muscatine Slough flowed through the Refuge, draining multiple lakes from the north, which likely maintained lower water levels within the lake and more of a flow-through system, based on General Land Survey Office (GLO) information.

3.3 Horseshoe Bend

This Division is located within the Iowa River HUC-10 (0708020911) and within the Otter Creek-Iowa River HUC-12 (070802091104) (Figure 5).

Land is primarily managed as marsh riverine/moist soil units, floodplain forests, wet/dry bottomland prairie or grassland. Water management is less intensive at this Division versus the Louisa Division. Regular flooding from the Iowa River has become more common as the levee has continued to degrade. The Division receives water through a number of levee breaches along the Iowa River, a drainage district to the northwest and various small un-named ditches along the northeastern flank of the Division. The areas to the northwest of the Division (within the acquisition boundary) are predominantly enrolled in the NRCS's Emergency Wetland Reserve Program, which is a permanent easement on the property that minimizes development.

Ridge and swale topography (or meander scrolls) is apparent in both the aerial and topographical imagery. These signatures, along with elevation information, indicate that this area was a historic flow-path for the Iowa River. However, this was likely prior to the 1830s, based on GLO Survey information. An evaluation of GLO maps, 1930s aerial and current imagery shows that the river bend on the northwest side of the Division has been migrating eastward, which caused levee degradation and a breach in 2013.

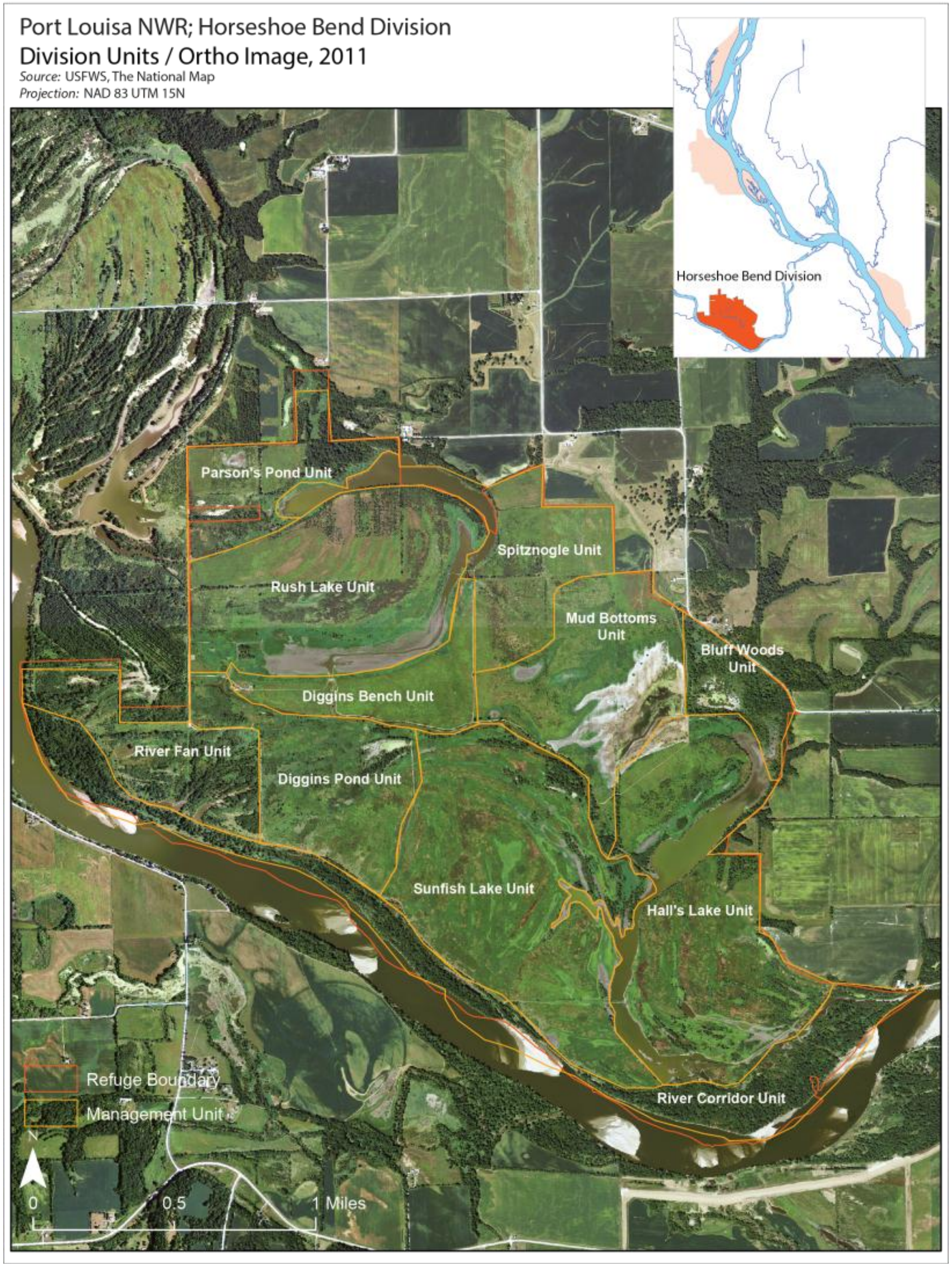


Figure 5 Horseshoe Bend Division boundary and 2011 aerial image

3.4 Keithsburg

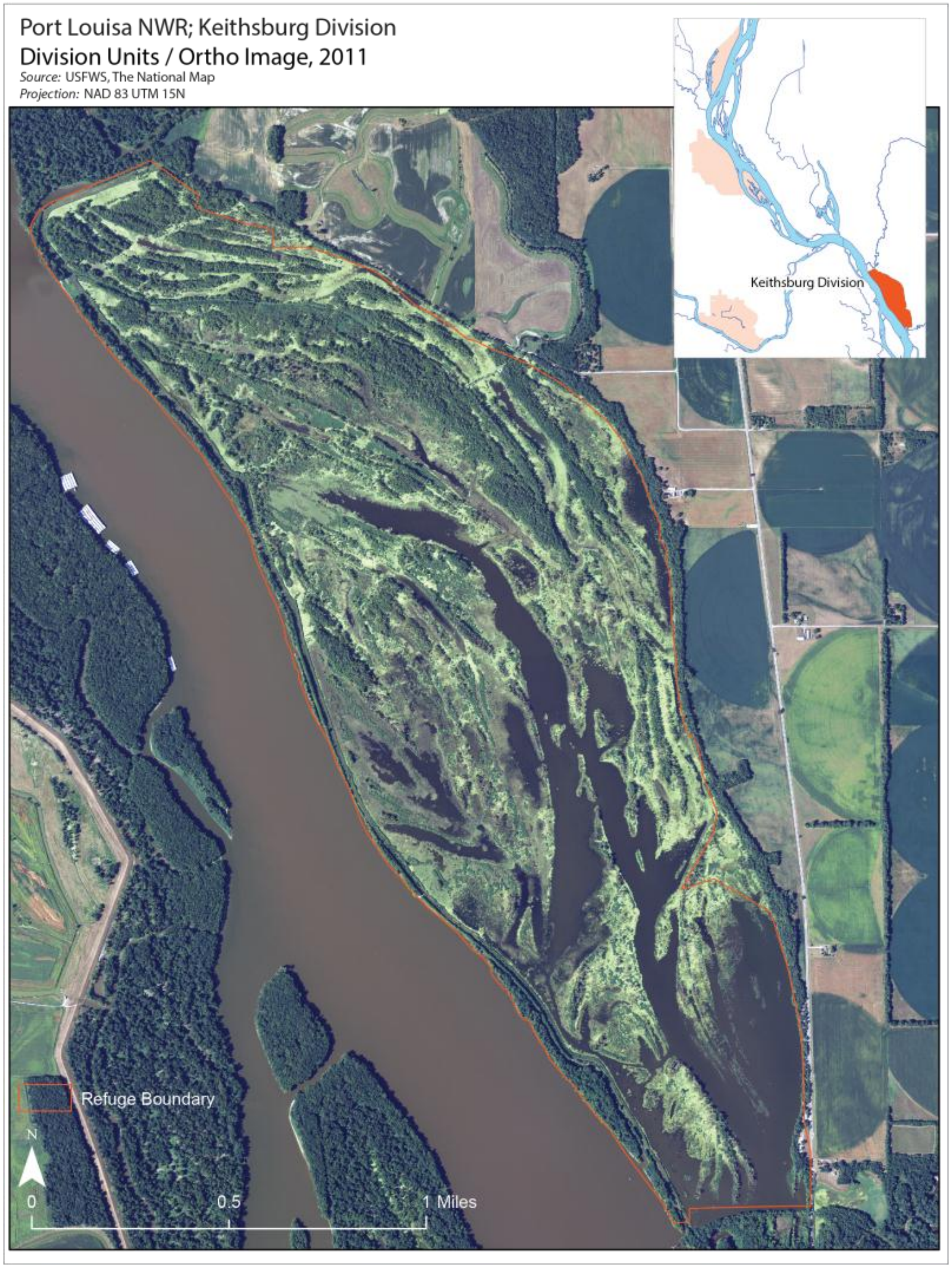


Figure 6 Keithsburg Division boundary and aerial image

The Keithsburg Division is located between Mississippi River mile 428 and 431, within the Dolbee Creek-Mississippi River HUC-10 (0708010406) and within the smaller Huron Chute-Mississippi River HUC-12 (070801040603) (Figure 6). The Division is primarily managed as marsh riverine and floodplain forests. Water enters the Division from a variety of sources. A WCS on the southwest edge of the Refuge is the primary means of water level control through gravity flow from the Mississippi River. Water also enters the Division through a spillway along the Edwards River, when at flood stage. Low to high flows from Pope Creek enter the Division from the south through a breach in the railroad levee. Flows through this breach create a freshwater estuary, which connects the Division to the Mississippi River. Additionally, there are four unnamed tributary ditches at the upper east side of the Keithsburg Division, which drain agricultural lands. One ditch on the northeast portion of the Division flows throughout the year. The other ditches have intermittent flows. The locally sandy soils tend to encourage pivot irrigation, which suggests the Division may be receiving large quantities of groundwater from both surface water and sub-surface infiltration.

GLO survey information shows the Division was within the active river meander belt (late Holocene) of the Mississippi River. As of 1807, a side channel of the Mississippi River was roughly coincident with the current eastern border of the Division and four islands may have existed, which became part of the Division. This side channel (or cutoff) of the Mississippi appeared to exist minimally until 1891. Major levees were subsequently constructed likely to facilitate the formation of the drainage district in 1909. Aerial photos suggest that the majority of the Division was under cultivation by 1927, with only remnant forest visible on the southern end of the modern Division boundary.

4 Natural Setting

Historically, the lands that now comprise PLNWR were located within the floodplain of the Mississippi and Iowa Rivers, which were a dynamic continuum of sloughs, islands, sandbars, and open water. Annual flooding and intermittent large floods changed the course of the river, creating new wetlands and depositing nutrient-rich sediments on forests and prairies, while summer low flows enhanced the growth of wetland vegetation.

The lands along the Mississippi River have been affected by the construction of flood levees, a series of locks and dams, wing dams, and other efforts designed to maintain a 9-foot deep navigation channel. Maintenance of this channel has increased typical low water Mississippi River discharge when compared to historical values (i.e. prior to 1938) in all of these stretches. These anthropogenic changes to the Upper Mississippi River have dramatically affected fish and wildlife habitat due to increased soil erosion, sediment deposition, reduced water clarity and destruction of fish habitat. The isolation and management of the Mississippi River from its historic floodplain have increased the likelihood of flooding at higher elevations through the reduction of upstream buffering areas (e.g. Theiling and Nestler 2010, Remo et al. 2009). Currently, cultivated crops, pasture and mixed hardwood forests surround the PLNWR Divisions (Figure 7).

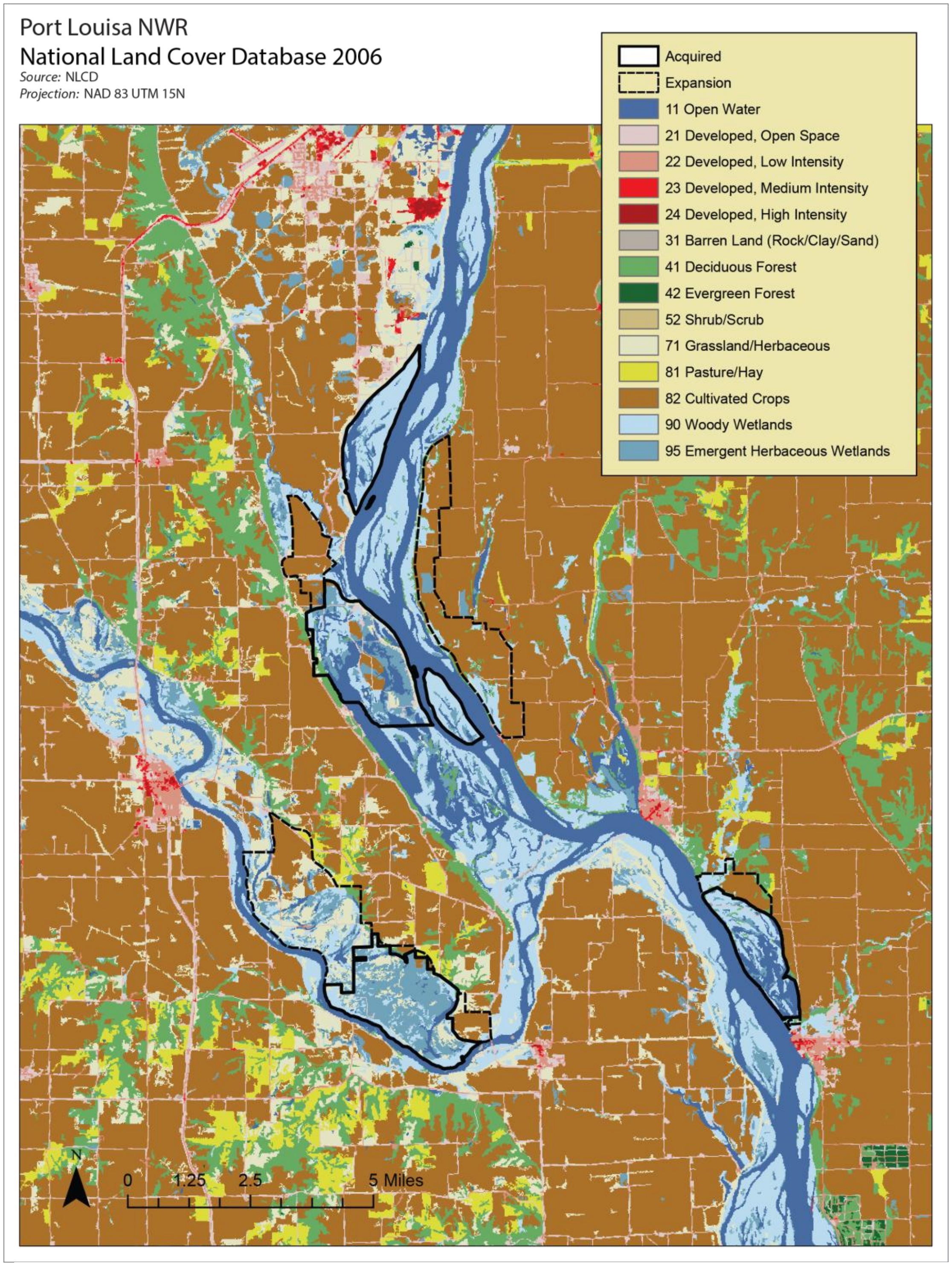


Figure 7 Regional land usage from 2006 National Land Cover Dataset (NLCD)

4.1 Topography

4.1.1 Iowa Divisions

High-resolution bare-earth (LiDAR) data is currently available for the PLNWR Divisions within Iowa from the Iowa DNR (Figure 8). This data was collected at a standard density (1.4-meter sample distance). Multiple returns were recorded for each laser pulse, along with an intensity value for each return. According to the specifications, automated and manual filtering of the LiDAR was completed for bare earth elevation models, which removes 90% of artifacts, 95% or better of all outliers, 95% of all vegetation and 98% of all buildings. Vertical elevation accuracy equals 18.5 cm root mean square error (RMSE).

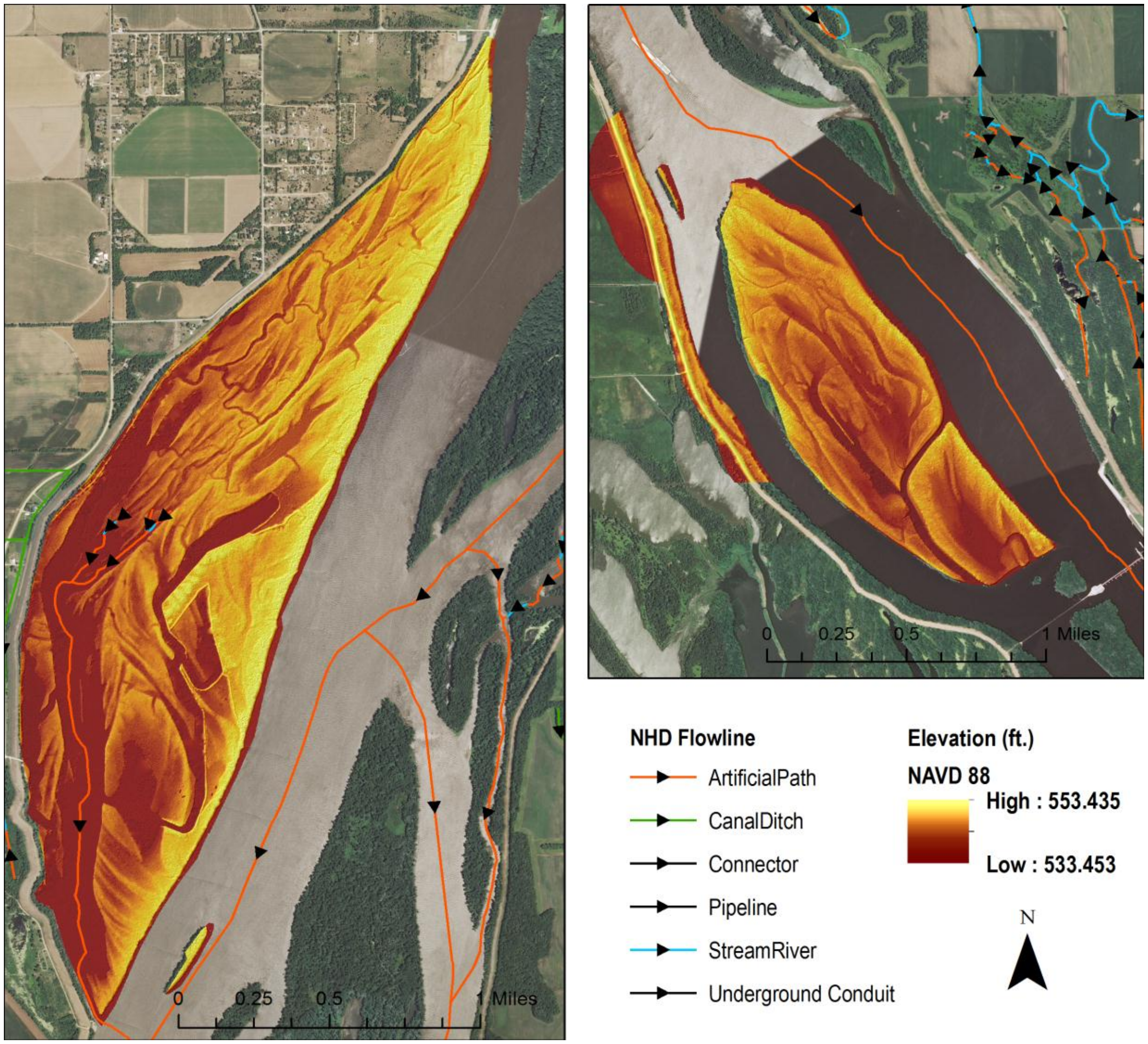


Figure 8 Elevation and NHD flowpaths for Big Timber Division islands

4.1.2 Keithsburg Division

High-resolution LiDAR data is currently in the QA/QC process for the Keithsburg Division. The preliminary data was obtained, which clearly illustrates the locations of spillways and levee breaches (courtesy Illinois USGS) (Figure 9). This data may be useful for determining flow paths, evaluating connectivity and potential habitat type determinations or delineations based on regularity of flooding, slope and aspect.

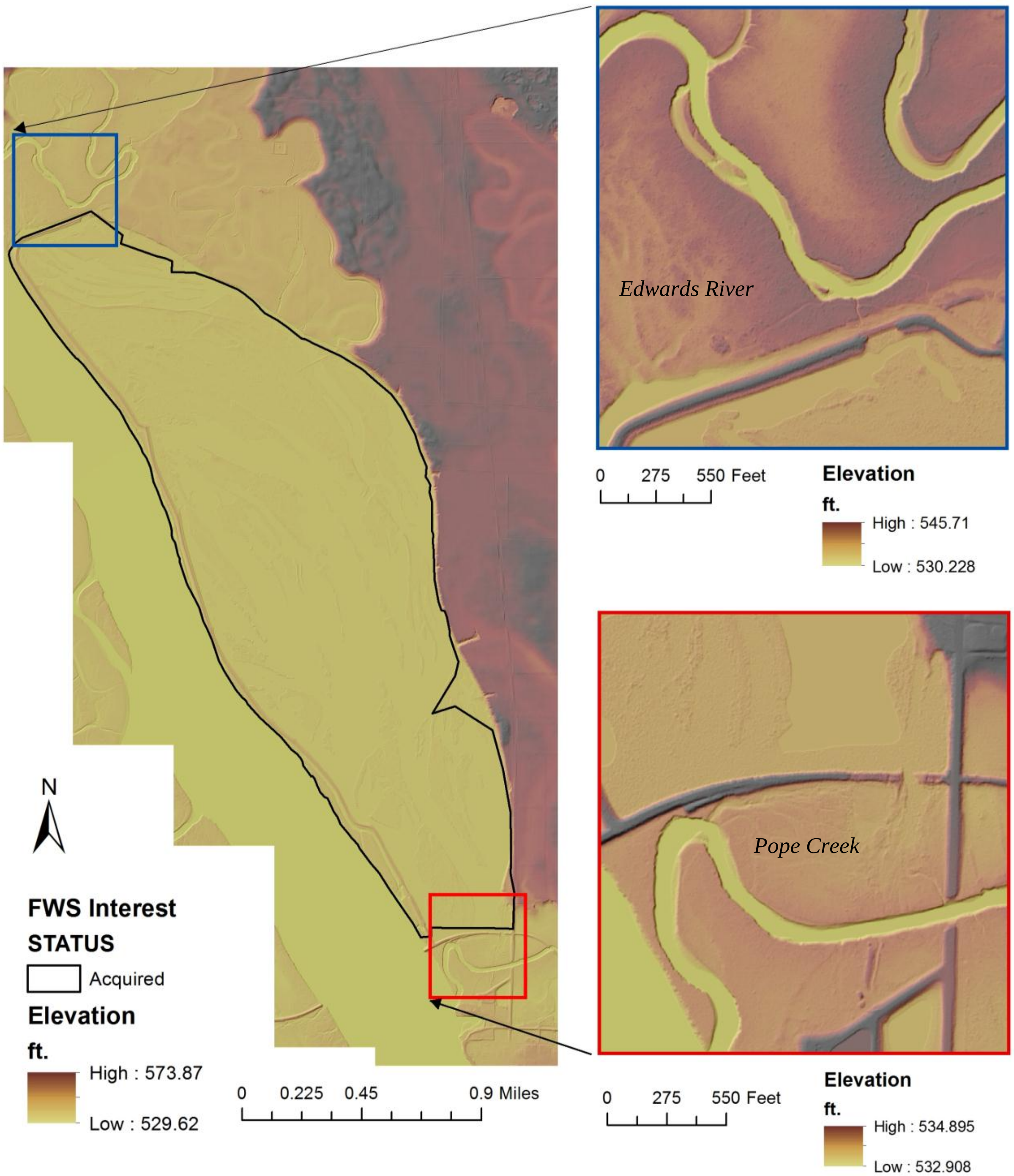


Figure 9 Elevation (LiDAR) for Keithsburg Division showing spillways and levee breach

4.2 Geology and Soils

The PLNWR units are located within the Southern Iowa Drift plain, which has surficial material consisting of pre-Illinoisan glacial deposits mantled by loess. Soils on the lower slopes are commonly derived from till, whereas soils on the higher slopes and upland flats are derived from loess. Loess is usually easily erodible, which will typically result in increased suspended sediments and nutrients relative to other basins with similar precipitation patterns. Typical habitats include oak-hickory forest and bluestem prairies (Griffith et al. 1994)

During glacial melting periods, the Mississippi River carried a significantly larger volume of water, which created the multiple terraces that are visible today and apparent on the PLNWR Divisions. In the alluvial valleys, some of the valley fill has scoured away, and subsequent river meander evolution and flooding have created the present day floodplain morphology and alluvial derived soils.

Existing soils are typically clay-loam and silt-loam formed primarily through alluvial processes. All of these soils are classified as either occasionally or frequently flooded by the Natural Resources Conservation Service (NRCS; SSURGO web soil survey). The official soil description for each of the soil types is available from the NRCS (Link). Soil drainage attributes show that most of the soils are "somewhat poorly drained" to "poorly drained" (Appendix C SSURGO soil classification and drainage type derived from soil classifications). Some well-drained sandy soils are located at the Louisa (Elrick Series), Horseshoe Bend (Perks Series) and Keithsburg (Sparta and Ade series) Divisions. The native vegetation based on SSURGO soil types is generally a mixture of prairie (grasses) and trees. Striation patterning of loamy soils at the Horseshoe Bend Division suggests prior to anthropogenic intervention, the Division exhibited ridge and swale topography typical of historical flowpaths of the Iowa River.

The underlying rocks in the Division are from the Middle Devonian period, typically 200 to 252 ft. below the surface. These rocks are limestone (dolomite), which formed, 393.3± 2.7 to 387.7± 2.7 million years ago. Limestone and shale are common in the area and exposed in some portions of the Mississippi River valley, but are typically not visible at the PLNWR Divisions.

4.3 Long Term Climate Trends

Climate is defined within the WRIA as the typical precipitation and temperature conditions over years or decades. Climate trends and patterns affect groundwater levels, river runoff, flooding regularity and flooding magnitude. The WRIA provides a broad overview and analysis of trends and patterns in precipitation and temperature for the region of the Refuge. Climate change predictions and trends are available from other more comprehensive studies, which have evaluated this part of the Midwest (e.g. Hayhoe et al. 2010, UCS 2009).

Weather information was obtained from the PRISM Climate Group at Oregon State University (Link). The PRISM interpolation method provides spatial climate information for the conterminous United States, partially based on data from approximately13,000 precipitation and 10,000 temperature stations. The dataset for temperature and precipitation is interpolated from nearby weather stations and corrected for elevation enabling point estimation. This was completed at the Louisa Division for comparison to data obtained from two sites from the U.S. Historical Climatology Network ([USHCN]; Menne et al. 2012). The USHCN is a network of sites listed by the National Weather Service, which maintains standards in quality and continuity of data collection.

The closest USHCN stations are located at Mt. Pleasant, IA (NWS COOP ID: 135796) and Washington, IA (NWS COOP ID: 138688), both west of the Refuge.

The USHCN site located at Mt. Pleasant, IA, had similar monthly averages and monthly normal (1981-2010) for precipitation, minimum and maximum temperature to data obtained from the PRISM Climate Group.

The typical historical climate patterns and predicted future trends found for the WRIA were:

1. The growing season (time between the last spring frost and the first autumn frost) lasts about 162 days, extending from April 26 to October 5 in central Iowa. It is about 15 days shorter along the Minnesota border and 20 days longer in southeast Iowa. At the Mt. Pleasant, IA station, there was a statistically significant trend (r^2=0.207; $p<0.01$) of increasing average minimum temperatures, particularly in the spring and fall for this site from 1950-2011 (Figure 10). This trend was not apparent for the average monthly mean or maximum temperature.

2. The USHCN weather station located at Mt. Pleasant, IA, showed a mean annual precipitation of 37.7 inches, with the highest rainfall typically in May or June (Figure 11 and Figure 12). For all of the stations precipitation was usually 3-4 inches per month from March through November. Climate scenarios suggest that floods and droughts are likely to become more common and more intense as regional and seasonal precipitation patterns may change. Heavy precipitation events have increased in this region and rainfall is more concentrated into heavy events, with longer, hotter dry periods in between (Kunkel et al. 2003).

3. Drought occurs periodically in Iowa with the most severe in historical times occurring in the 1930's. Other major droughts, usually characterized by deficient rainfall combined with unusually high summer temperatures leading to rapid soil moisture depletion, occurred in 1886, 1893 - 1894, 1901, 1955 -1956, 1976-1977, 1988 -1989 and 2012. The frequency of these events is expected to increase based on existing climate forecast models and current trends.

4. Mean temperature is typically highest in July or August and coolest in January or December. Long-term temperature records show that the last 10 years were particularly warm, and 1960, 1978, 1979 and 1993-1996 were particularly cold. There is some evidence for an increase in mean temperature values across the period of record.

5. Climate scenarios are very mixed, with one climate projection scenario suggesting a 13-15° F increase may happen by the end of this century (UCS 2009). Another scenario suggests an increase of only 0.018 ° F/year or approximately 1.6 ° F by 2100 (Magness et al. 2011).

6. There is not currently a pattern of increasing drought, but increasing average summer day and evening temperatures may lead to reductions in soil moisture. Higher temperatures will increase evapotranspiration, which will lead to less runoff from precipitation events and regular drought conditions.

7. The WRIA compared temperature and precipitation deviations from normal at the Mt. Pleasant, IA station to the Southern Oscillation Index (SOI) climate teleconnection. Extreme positives and negatives in SOI index are commonly known as El Niño and La Niña, which are opposite phases of the El Niño-Southern Oscillation (ENSO) cycle. The ENSO cycle describes the fluctuations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific. We were unable to resolve any trends in a simple comparison between the SOI and the Mt Pleasant, IA site. However, the State Climatologist Office for Illinois (Dr. Angel; Link <accessed 10/1/2013>) summarized the typical impact of ENSO in Illinois as:
    a. El Niño events will tend to promulgate cooler and wetter summers/falls, and warmer and drier winters (see Changnon et al. 2000).
    b. La Niña impacts are not as clear, but typically winters will be wetter and warmer and summers will be warmer and drier.

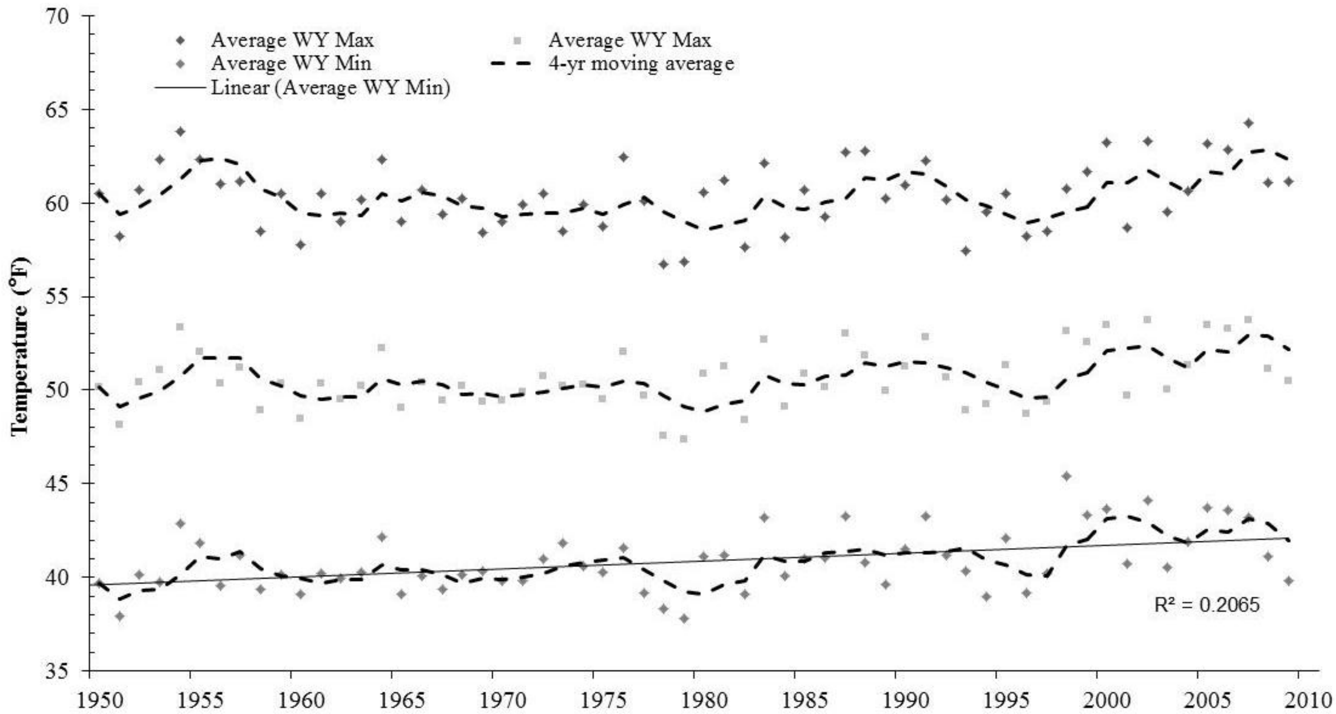


Figure 10 Water Year (Oct. 1-Sep. 30) Temperatures 1950-2011 at Mt. Pleasant, Iowa (135796). The average minimum temperature had a statistically significant trend of increasing temperature

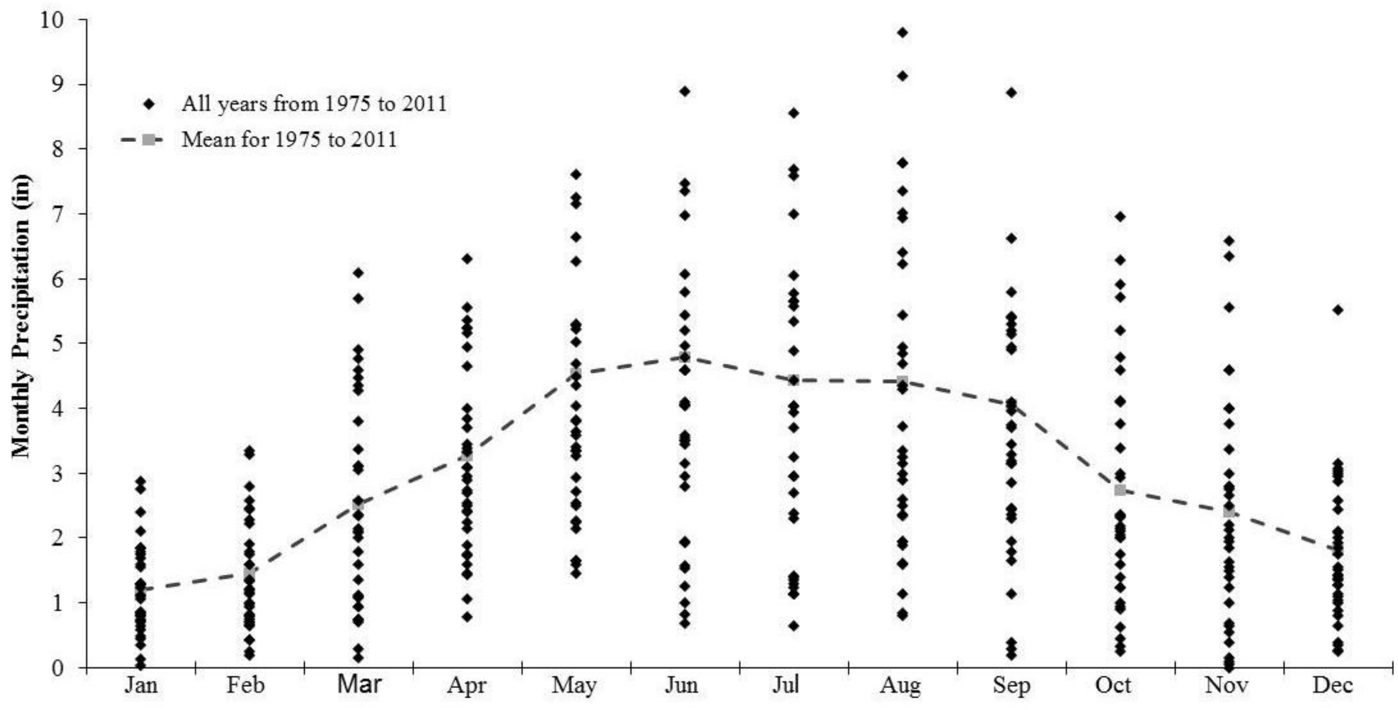


Figure 11 Mean and Distribution of Recent Monthly Precipitation 1975-2011- Mt. Pleasant, Iowa (135796)

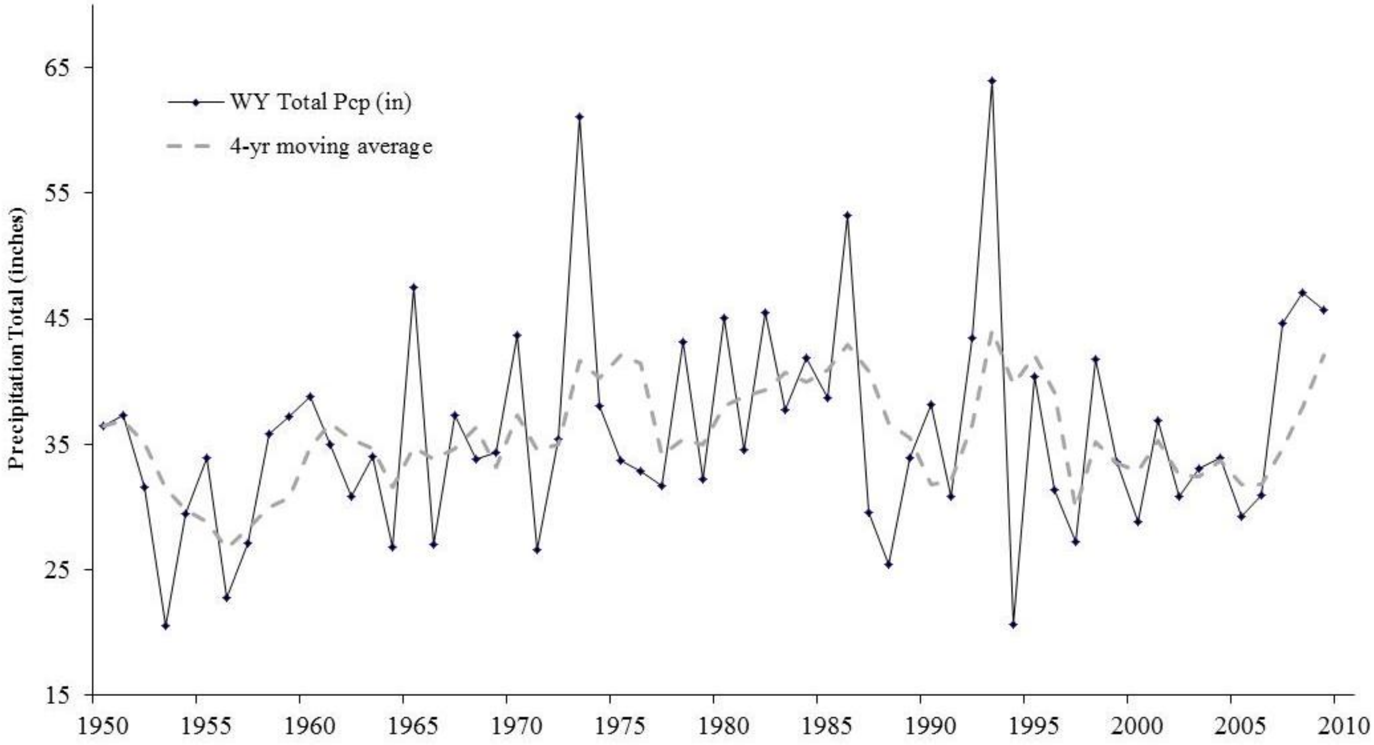


Figure 12 Water Year (WY) total precipitation 1950-2011- Mt. Pleasant, Iowa (135796)

5 Water Resource Features

5.1 Wetlands and Bottomland Prairies

The National Wetland Inventory was completed using color Infrared images from 1984 for most of the Iowa Divisions, and in 2002 for Keithsburg, based on the classification scheme identified in Cowardin et. al. 1979 (Appendix D National Wetland Inventory (NWI) images and summary statistics). The Louisa Division is classified by the NWI as 67% wetlands; containing lake (23%), palustrine emergent (18%) and forested/shrub (26%) wetlands. The wetlands were typically categorized as temporary seasonally flooded. The Big Timber Division was classified as 99% wetlands, primarily lake (27%) and seasonally/temporarily flooded forested (69%) wetlands. Keithsburg was 96% wetlands, primarily lake (52%) and forested wetlands (39%), which were seasonally or semi-permanently flooded. Horseshoe Bend Division was 31% wetlands, containing: lake (7%), emergent (10%) and forested/shrub (12%), which varies significantly depending on the flooding regime.

5.2 National Hydrography Dataset (NHD) Flowlines (streams, creeks and ditches)

NHD flowlines were clipped to a ¼-mile buffer of the Refuges acquisition boundary and summarized based on named features and feature types (i.e. USGS FCodes) (Appendix B Topographic image for PLONWR). Approximately 77.6 miles of NHD flowpaths were identified in the Big Timber, Louisa, Horseshoe Bend, and Keithsburg Divisions, 27.29 miles (35.17%) of which are named. The flowpaths can be broken down based on type: 3.92 miles (5.05%) as perennial streams and rivers, 21.3 miles (27.45%) as intermittent streams and rivers, and 52.11 miles (67.15%) as canals, ditches, or artificial paths.

Important named features in the Big Timber Division include the Mississippi River (4.26 miles) and Coolegar Slough (2.26 miles), which is the permanent backwater area within the Division.

In the Louisa Division, 1.92 miles of the Mississippi River were identified through the acquisition boundary and buffer zone, as well as 1.45 miles of Michaels Creek and 0.07 miles of Bogus Chute. The artificial path in the southwest portion of this Division is not labelled, but represents a portion of Odessa Lake. The total area of this lake is approximately 6,760 acres, though only a fraction of this is federally owned. Similarly, the short artificial path paralleling the Mississippi River in the east corresponds with flow through Fox Pond. Horseshoe Bend has the largest proportion of NHD flowlines identified between these four Divisions (41.91 miles, 54%). In Horseshoe Bend, 8.72 miles of the Iowa River were included in the NHD, as well as 2.74 miles of Diggins Slough, 0.41 miles of Smith Creek, and 0.34 miles of Otter Creek. Sunfish Lake is not labelled on the NHD but is located at the end of the Diggins Slough flowpaths.

The Keithsburg Division included the Mississippi River (3.45 miles), Pope Creek (0.91 miles), and Edwards River (0.76 miles) named features. High water levels in this Division can increase connectivity between water features, making it difficult to distinguish the waterways on aerial images that correspond with NHD flowpaths.

Figure 13 Stop-log structure typical of those found at Port Louisa NWR

5.3 Water Control Structures (WCS)

Fifty-nine WCSs were identified for the WRIA, which include a combination of stop-log structures, screw gates, culverts and pumping stations (Appendix B Topographic image for PLONWR). Big Timber does not have any water management structures and only two (1 functional) structures were identified at Keithsburg. The majority of the structures were located at the Louisa and Horseshoe Bend Divisions. Stop-log (or board-stop) structures were the most common structure. Stop-log structures maintain the water below a set elevation, which is controlled by the placement of boards (Figure 13).

6 Water Resource Monitoring

The WRIA identified historical and ongoing water resource related monitoring on or near the Refuges. Water resource monitoring is divided broadly between quality and quantity monitoring for surface water features or groundwater. For the purposes of the WRIA, water quantity and quality information were briefly evaluated for applicability, period of record and trends. Water quantity monitoring typically includes a stage and/or discharge measurement in a stream or aquifer. Water quality can include laboratory chemical analysis, deployed sensors or biotic sampling such as fish assemblages or invertebrate sampling. Biotic sampling is often used as an indicator of biological integrity, which is a measure of the stream purpose attainment by state natural resources management organizations. There are multiple resources to retrieve sampling data for the Division. These include:

- The EPA Great Rivers assessment includes datasets for the Mississippi River (Link).
- Multiple State environmental protection and natural resource management agencies collect water chemistry information. This data is occasionally stored in STORET (below), on state websites and is sometimes available only by request. For example, additional information was available for the Edwards River from the IEPA, by request.
- The USGS long-term research and monitoring program (Link) has both regular monitoring sites and irregular monitoring sites within the Mississippi River pools.
- Data for historical sampling locations can be retrieved through EPA STORET (STOrage and RETrieval; Link) database based on ID number. The STORET data warehouse is a repository for water quality, biological, and physical data used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others.
- Data for historical sampling and active sampling sites for the USGS are available from National Water Information System (NWIS; Link).

Generally, water quality criteria for nutrients and other contaminants are based on EPA recommendations or rules in lieu of the adoption of stricter regulations at a state level. Currently, Iowa and Illinois have not developed state-specific criteria or formally adopted EPA approved criteria for total nitrogen (TN) and total phosphorus (TP) in streams and rivers. Current EPA recommended criterion for TP were often exceeded at sites relevant to Refuge Divisions. TN and Chlorophyll (Chl) concentrations were typically very close to the recommended criteria (Table 1).

	Lakes and Reservoirs	**Rivers and Streams**
TP µg/L	20	36.56
TN mg/L	0.36	0.69
Chl a µg/L	4.93	0.93
Secchi (m)	1.53	5.7

Table 1 EPA recommended water quality criteria for Southeastern Temperate Forested Plains and Hills (Ecoregion IX; Level III)

6.1 Water Monitoring Stations and Sampling Sites

A list of sites that are relevant to the resources of concern or that are currently inactive was also created (Table 4). Data was collected from the EPA STORET database and the USGS NWIS database. Surface water stations were considered indirectly applicable if they were located within the HUCs of interest and/or drainage areas adjacent to Refuge property. Seventy-six sites were identified, primarily compiled by the U.S. EPA, Illinois EPA or Iowa DNR.

There are staff gages installed at multiple locations on the Refuges. There are six staff gages located at Horseshoe Bend Division and eight staff gages located at the Louisa Division.

6.2 Surface Water Quantity

Compared to historical records, annual stream hydrographs are changing due to a number of possible factors including changes in precipitation and temperature. There has been an approximate 27% increase in days with heavy precipitation for this region from 1958-2007 (Groisman et al. 2005). These heavy precipitation events lead to flash flooding and increased erosion. The expectation is for earlier and higher peak runoff from the larger snow-driven rivers (e.g. Mississippi River, Iowa, etc.) in the area, and large variability in expected runoff from smaller rivers. However, despite long-term increases in heavy precipitation and runoff in this area over the last century, climate projections do not anticipate continued large increases in runoff (Lettenmaier et al. 2008; Hayhoe et al. 2010). Runoff is not anticipated to continue increasing because of stagnant land usage, less overall precipitation and increased evaporation.

In our assessment of the patterns in surface water quantity, we compared several of the sites qualitatively to a reference hydrograph obtained from the Hydro-Climatic Network site, and we evaluated trends over time for peak discharge, average annual discharge, and average monthly discharge. The Hydro-Climatic Data Network (HCDN) is a network of stream gages located within relatively undisturbed watersheds with minimal anthropogenic influences, which are appropriate for evaluating trends in hydrology and climate that are affecting flow conditions (Slack et al. 1992). This network attempts to provide a look at hydrologic conditions without the confounding factors of direct water manipulation and land use changes.

The Edwards River near Orion, IL (USGS 05466000) is the closest site that meets the criteria for the HCDN. The site shows lower discharge during the 1950s to 1960s. Simple linear regression suggests an upward trend in average annual discharge, but there are no statistically significant trends. The available data does not indicate a long-term hydro climate change for the river at the HCDN (Figure 14). This type of finding suggests that the observed change in discharge in other more disturbed basins may be a function of land use practices and not necessarily indicative hydro-climate change.

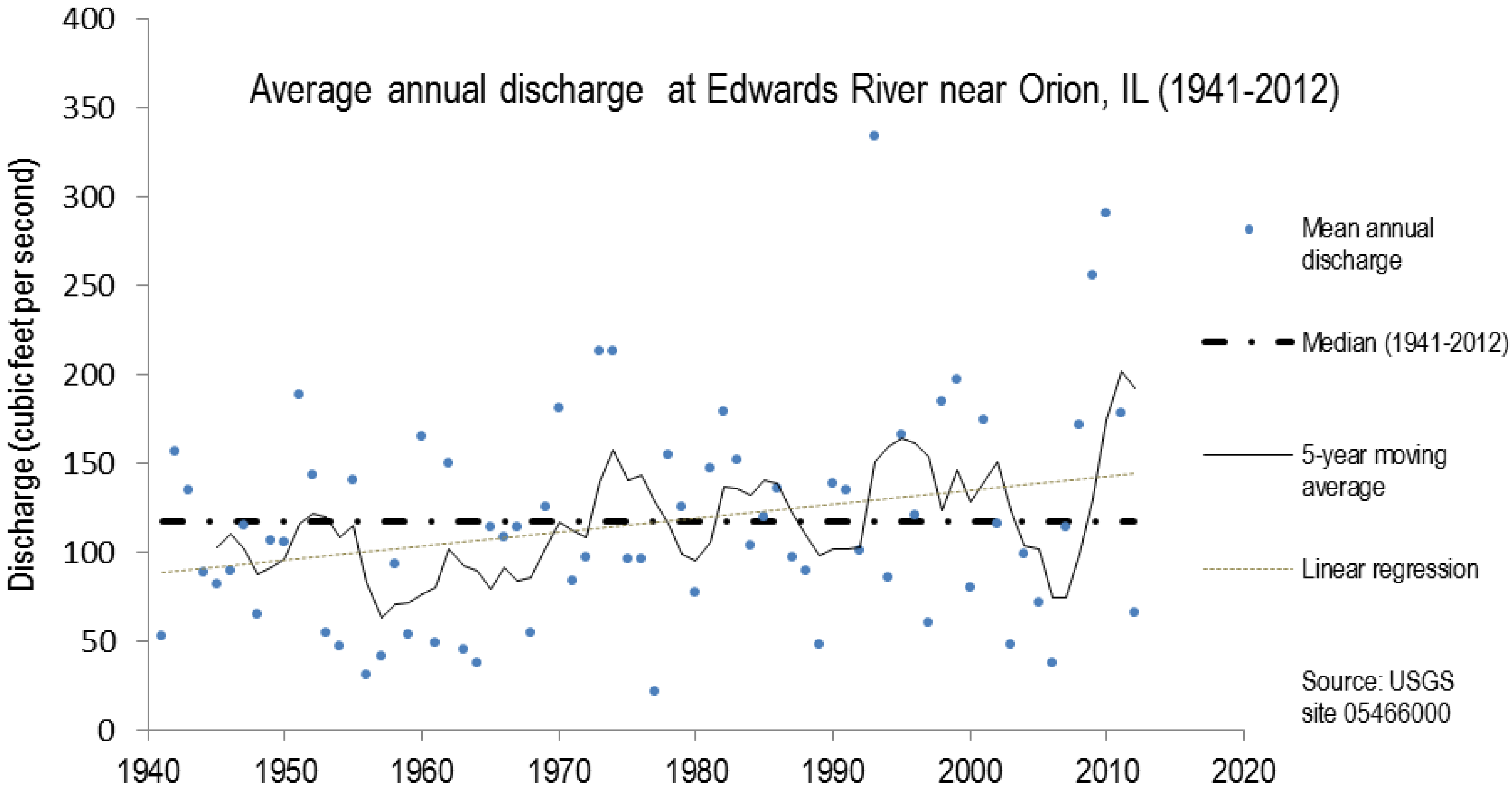


Figure 14 Average annual discharge at Edwards River near Orion, IL (1941-2012)

6.2.1 Lake Odessa- U.S. Fish and Wildlife Service water level and temperature monitoring

The USFWS initiated a monitoring station at Lake Odessa at the Louisa Division and Odessa Wildlife Management Area. This gage site contains a WaterLOG® Design Analysis data logger in metal gage housing, mounted to fence posts. The data logger is in communication with a pressure transducer mounted to fence post near the lake-bottom. The instruments are powered by a 12V battery, charged by a solar panel, mounted to an antenna mast. Weekly water level gage and temperature data is available online (Figure 15 andFigure 16) (NWS ID ODSI4) and yearly station reports are generated by USFWS hydrologists (2012 station report; ServCat reference 24340). This gage station provides a continuous data set, which is useful for biological surveys/studies, water budget calculations and real-time information on the effect of water control structure manipulation.

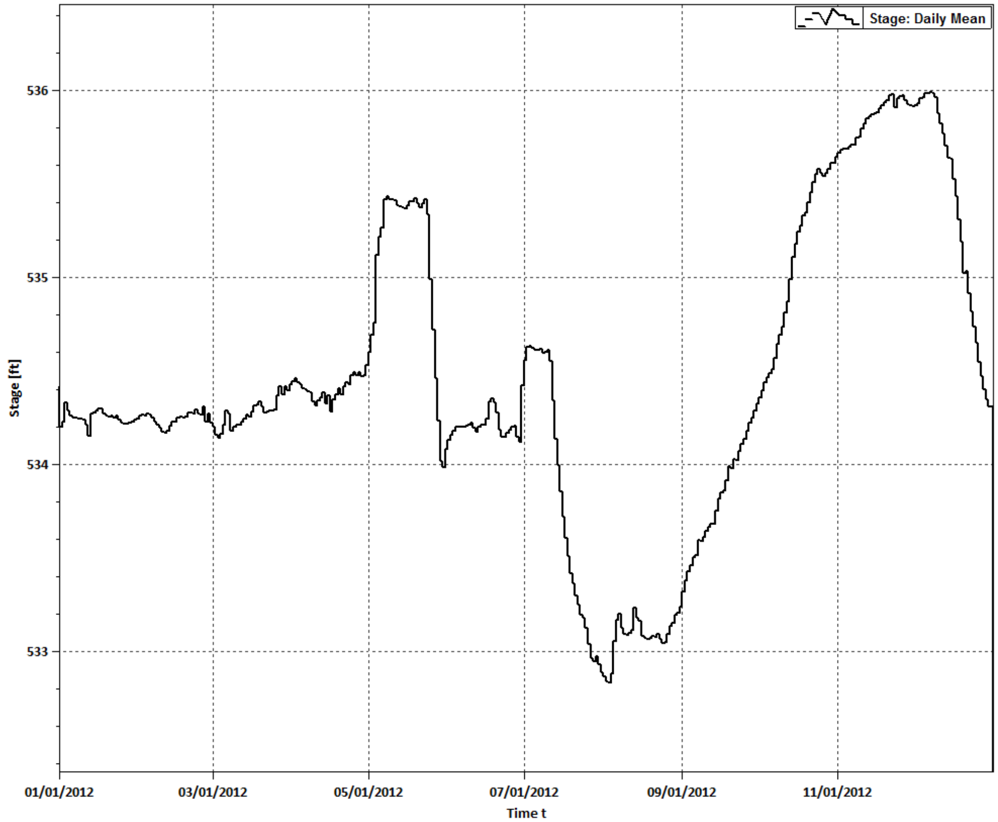


Figure 15 Stage (mean sea level) for Lake Odessa (2012)

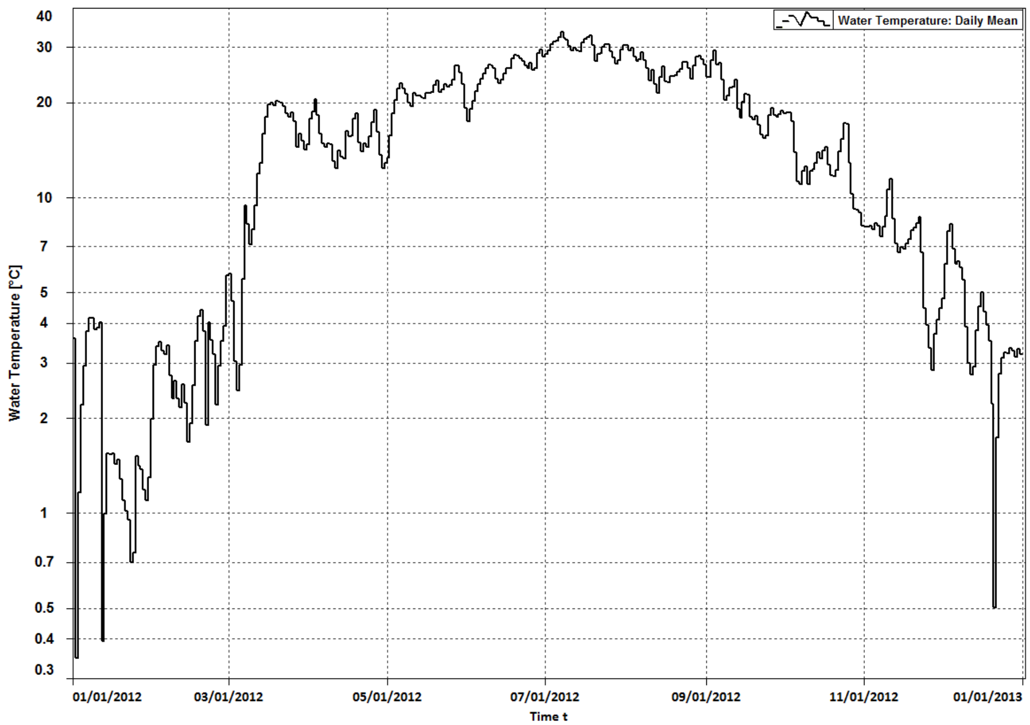


Figure 16 Temperature (°C) for Lake Odessa (2012)

6.2.2 Edwards River

The Edwards River runs along the northern boundary of the Keithsburg Division. Water from the Edwards River can enter the Division through a spillway cut into the levee on the northeast portion of the Division. Based on LiDAR elevation information, the elevation of this levee is approximately 545 ft. above msl (NAVD 88) and the spillway is approximately 539.75 above msl (NAVD 1988). Typically the measured peak discharge for the Edwards River is in April or May (Figure 17), but high discharge may also happen during a winter rain event. From 1935 to 2012, the median annual peak discharge was 4,360 cubic feet per second around April 30 at this location (Figure 18). Flash-flooding from heavy rainfall is most frequent in the overnight hours from June through September. Flooding at the Keithsburg Division also occurs during periods of high flow on the Mississippi River, when the Mississippi River acts as a hydraulic dam that slows flow and raises water levels in the Edwards River. An analysis using the Indicators of Hydrologic Alteration (IHA) qualitatively suggests that the date of peak discharge is happening slightly later in the year, and that peak flows during May have increased (Appendix E Most significant measured indicators of hydrologic alteration for the Edwards River at New Boston).

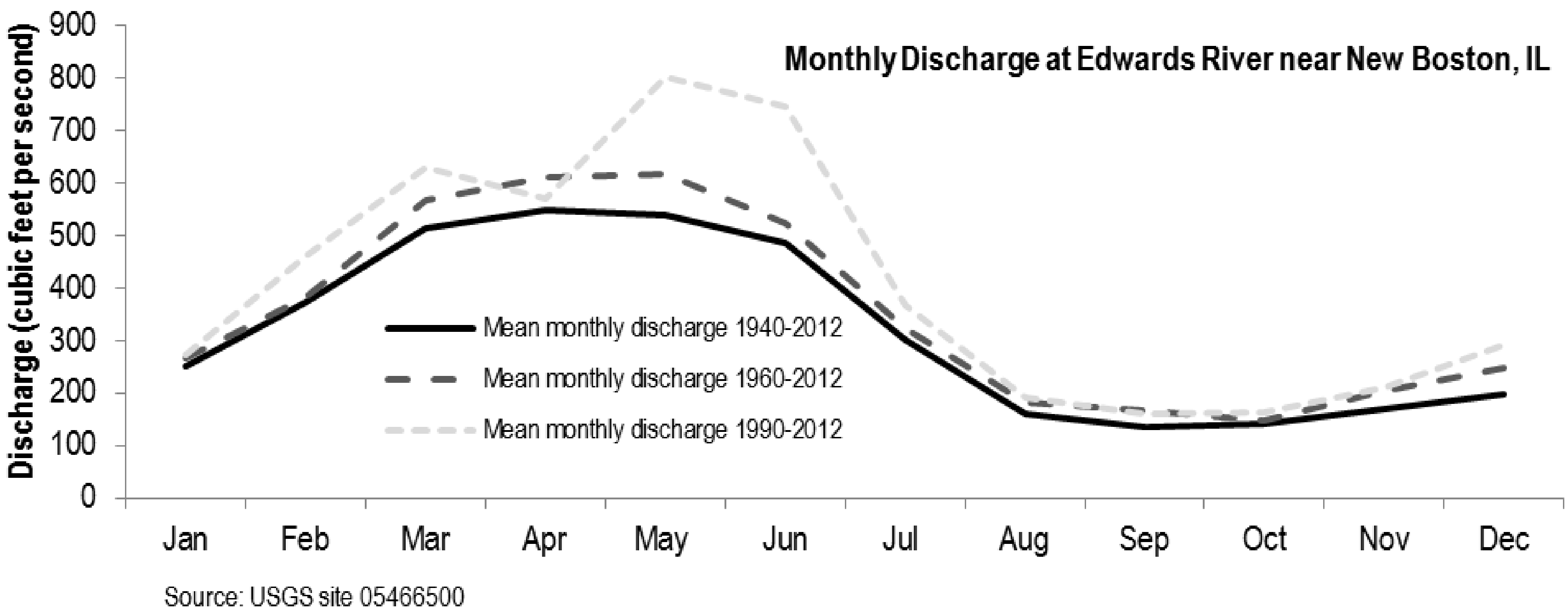


Figure 17 Mean monthly discharge at Edwards River near New Boston, IL

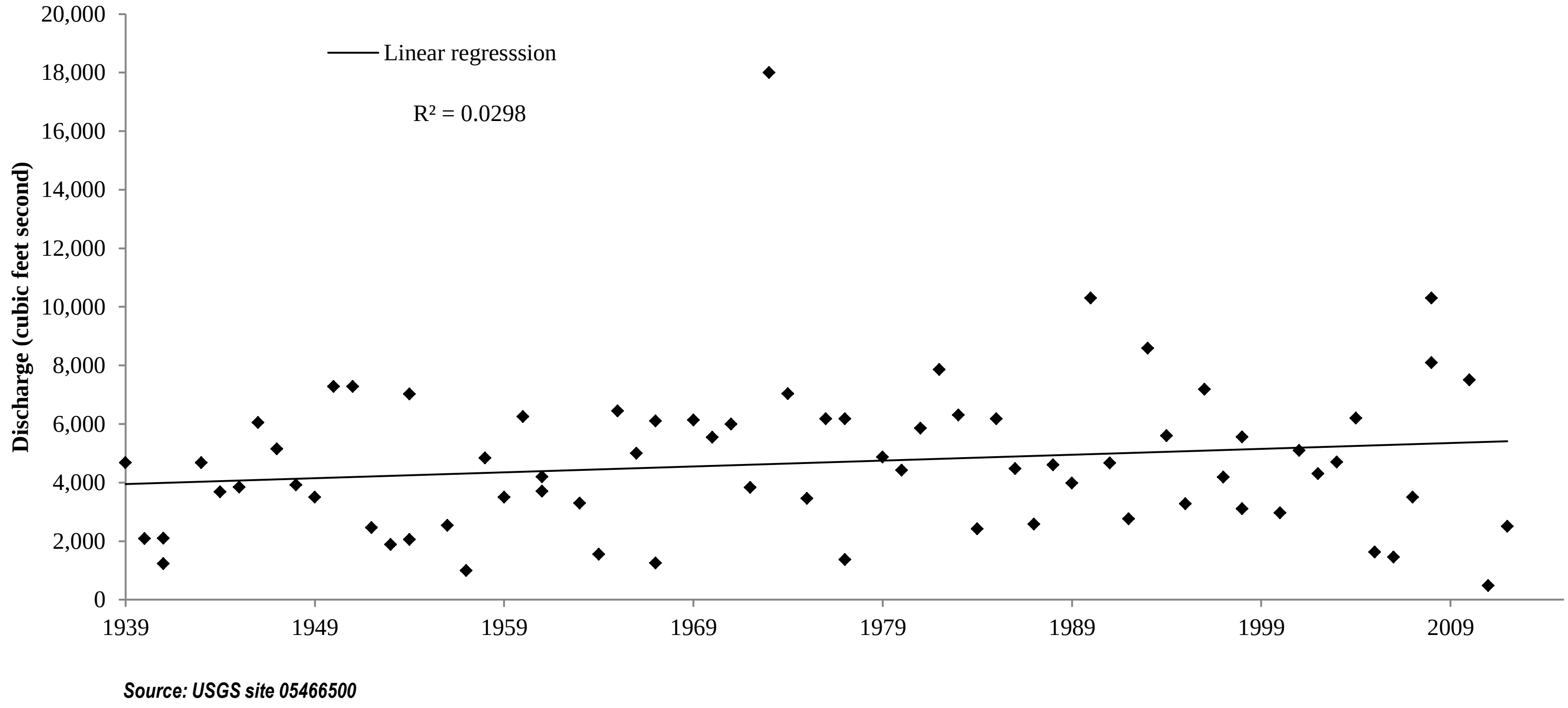
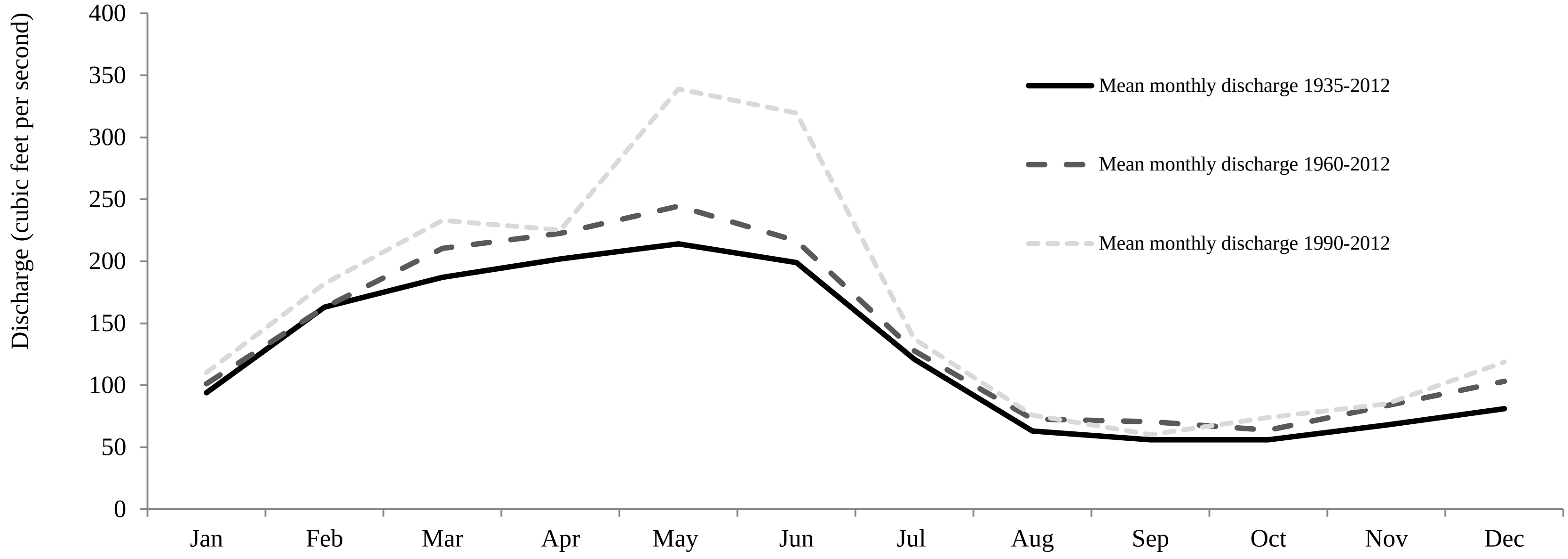


Figure 18 Annual peak discharge at Edwards River near New Boston, IL

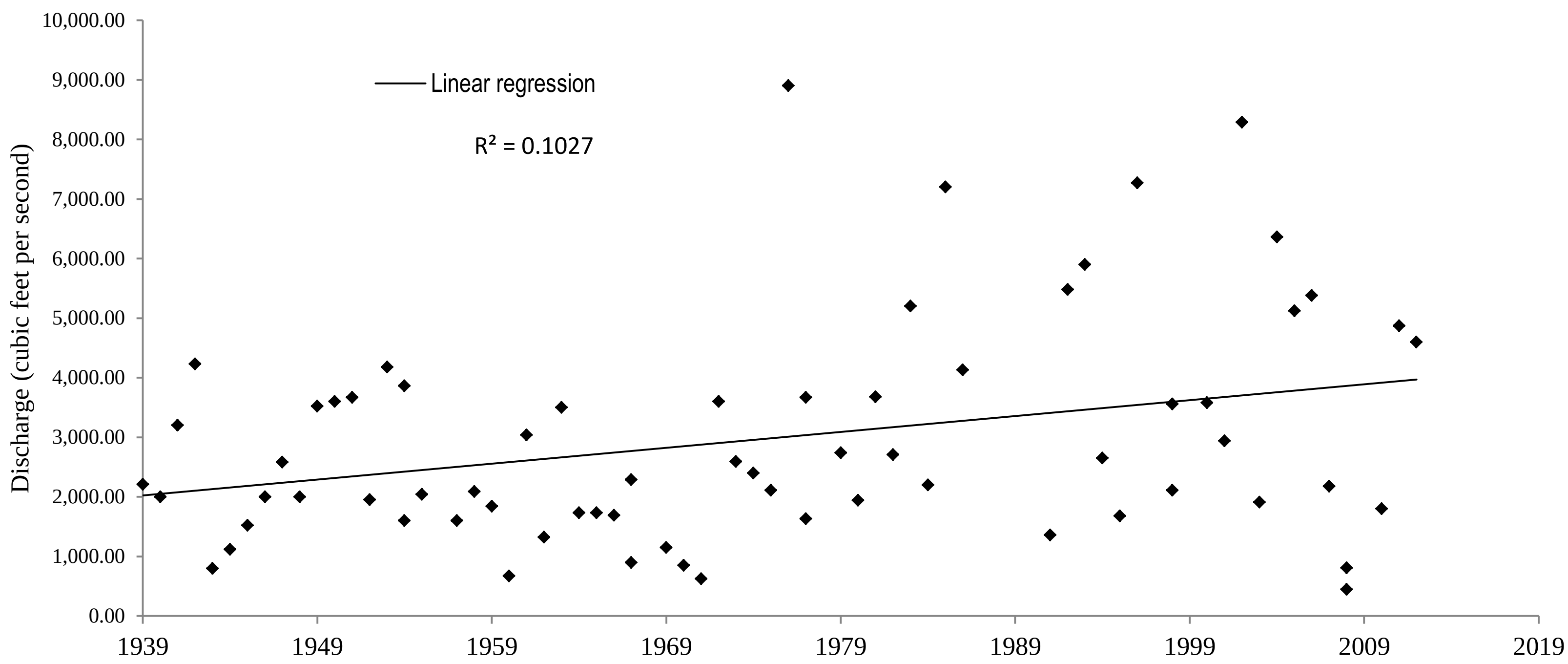
6.2.3 Pope Creek

Pope Creek flows by the southern boundary of the Keithsburg Division. Pope Creek is smaller than the Edwards River, but has similar trends over the period of record (Figure 19). Annual peak discharge does, however, demonstrate a statistically significant ($p<0.01$) increase over the time period (Figure 20), which was not apparent for the Edwards River. The Creek typically peaks in April or May, with a median annual peak discharge of 2,400 cubic feet per second for the period of record (1935-2012). Currently, there is a levee breach that allows water to enter Keithsburg Division at approximately 533.5 ft. above msl. At this elevation, there is roughly an 80% chance of water entering through this breach.



Source: USGS site 05467000

Figure 19 Mean monthly discharge at Pope Creek near Keithsburg, IL



Source: USGS site 05467000

Figure 20 Annual peak discharge at Pope Creek near Keithsburg, IL

6.2.4 Iowa River at Wapello

Analysis of the Iowa River at Wapello gage indicated that there has been an increase in base flow as a percentage of total discharge from 1986-2006 compared to 1958-1985. This information is based on a comparison of base flow index (BFI) for these two periods (see Eash and Barnes 2012 for BFI calculation). The BFI is the proportion of the discharge attributable to base flow, as determined using the BFI application (Link). The medians of the annual BFIs were 0.652 (1958-1985) and 0.705 (1986-2006), which is roughly a 9% increase in base flow. The difference in BFIs for these two periods is statistically significant (P = <0.001; Mann-Whitney Rank Sum Test). There could be multiple possible explanations for base flow increasing, such as changing land use, upstream drainage practices (potential increased efficiency and density), reservoir management or precipitation patterns.

The Iowa River at Wapello gage data (1958-2012) was also evaluated using the IHA program (IHA; The Nature Conservancy):

- Typically high flow pulses (>75% of daily flows for the period) are not happening as often, but have a longer duration.
- The rising limb of river discharge for these larger flood events is happening faster (i.e. +cfs/day) and falling slower.
- Over the period of record, median monthly median flows have increased, particularly in May and June.

Data from this gage station was also used in a regulated flow frequency study of the Iowa River (USACOE, 2009). The Bulletin 17B method (IACWD 1982) was used to derive discharge values for a range of return intervals, and the limitations of this method are discussed within the USACOE report. The 1-day annual maximum regulated flows for 10-1000 year flood events were derived from the Wapello gage station data (USGS 05465500) and are summarized in Table 2 (USACOE, 2009).

Exceedance Probability	Recurrence Interval (years)	Discharge (cfs)
0.1	10	73160
0.04	25	86090
0.02	50	121050
0.01	100	139790
0.005	200	159040
0.002	500	185340
0.001	1000	205890

Table 2 1-day annual maximum frequency curve for Iowa River at Wapello, IA (USGS 05465500) (USACOE, 2009)

6.2.5 Mississippi River model flood return interval

Mississippi River pool elevations and discharges are controlled by the lock and dam system, below flood stage, to ensure navigation and reduce flooding. The pools will have a typical elevation, which is maintained throughout the year. However, when water discharges exceed the capacity of the lock and dams, flooding can happen at the Port Louisa NWR Divisions. The most recent modeling of Mississippi River discharge and elevation is available interpolated for each Mississippi River mile from an online tool developed by The U.S. Army Corp of Engineer-St Louis district (USACE 2004; Table 3 and Appendix E Most significant measured indicators of hydrologic alteration for the Edwards River at New Boston). These values were developed using an unsteady flow hydrologic model in combination with the Bulletin 17B method (IACWD 1982) to derive flood elevations for 2 to 200 year events (Table 3). The return interval (often referred to as 'flood frequency') is the probability of reaching a particular maximum discharge for a given location on the River in any given year. For example, the 5-year return interval has a 1 out of 5 (20%) probability of occurring in a given year, and a 100-year return interval has a 1% chance of occurring in a given year. These calculated return intervals can be an underestimate, due to changing underlying flood pressures. Changing land use and climate are the primary drivers, which invalidate the typical methods of utilizing the entire period of record as a basis of flood elevations calculations (USACE 2004). The limitations of the methods in Bulletin 17B, Federal Guidelines for Determining Flood Flow Frequency (IACWD 1982), are discussed within the most recent modeling effort.

River mile	**446-440**	**446 (Big Timber)**	**443 (N. Port Louisa)**	**440 (S. Port Louisa)**	**431-428**	**431 (N. Keithsburg)**	**428 (S. Keithsburg)**
	Discharge	**Elevation (ft.)**	**Elevation (ft.)**	**Elevation (ft.)**	**Discharge**	**Elevation (ft.)**	**Elevation (ft.)**
2-year	149,000	543.0	542.5	541.3	167,000	537.4	536.5
5-year	197,000	546.7	546.0	545.1	218,000	540.6	539.2
10-year	227,000	548.1	547.3	546.4	250,000	542.3	540.8
25-year	264,000	550.4	549.6	548.8	289,000	544.1	542.5
50-year	291,000	552.1	551.3	550.8	318,000	545.4	543.6
100-year	315,000	553.5	552.7	551.8	346,000	546.4	544.6
200-year	340,000	554.6	553.8	552.9	372,000	547.4	545.5

Table 3 Mississippi River flood frequencies (NGVD 1929)

The Rock Island District Corp of Engineers gage located at Pool 17, or the Mississippi River gage located near Keithsburg, IL are the most relevant water level gages for determining if water levels are exceeding the levee, or to determine the regularity of inundation.

6.3 Groundwater elevation and quality

Unconfined sand and gravel aquifers are adjacent to the PLNWR. These aquifers have relatively short residence periods as water infiltrates and recharges rapidly. Some of the shallow groundwater wells in the sand terraces along this reach of the Upper Mississippi River are contaminated with high calcium, iron, nitrate, and pesticide chemicals (USGS, 2000). The contaminated groundwater can discharge into surface waters at locations along sandy bluffs or escarpments. There are drinking water advisories for high nitrate concentrations in shallow potable wells along some areas of the Upper Mississippi River valley sand terraces due to the rapid infiltration of farm runoff.

However, a review of some up-gradient wells in Mercer County, IL (Keithsburg Division), suggest that water quality in this area is good. Groundwater wells within Mercer County vary in depth, possibly receiving water from either sand and gravel aquifers or deeper bedrock aquifers. The CAP highlighted some of the potential exposure pathways (Coffey et al. 2012).

> *The areas to highlight for groundwater transport pathways into Refuge units include the shallow groundwater of two major sand terraces. One sand terrace is west of the escarpment along the west boundary of Louisa Division. The other sand terrace*

is east of the escarpment along the east boundary of Keithsburg Division. Rainwater infiltrates into the sand terraces and quickly transports down gradient as shallow groundwater through the sandy soils to discharge along the escarpments into surface waters of the Refuge units. The groundwater pathway may also be similar for Big Timber Division. The water volume and contaminant load in the groundwater along these pathways may be greater than many, if not all, of the smaller sized streams and ditches that flow into the Refuge units. Sand terraces provide a large footprint for water infiltration with high permeability, while the streams and ditches have relatively smaller drainage area footprints.

6.4 Surface Water Quality

There were numerous water quality monitoring sites found in the EPA STORET database within the four 10-digit HUCs. However, many of these sites have no data, limited datasets or were not in a location considered relevant by U.S. FWS hydrologists. Water quality information was also obtained directly from the Illinois EPA. Available water chemistry information was primarily for sample sites along the Mississippi River and other tributary streams that were adjacent to the Divisions. Based on the location of the monitoring site and availability of water chemistry data, sixteen sites were considered applicable to the Divisions (Table 4).

Water quality standards and the methodology associated with measurements are listed in Chapter 61 of the Iowa Administrative Code (Link). The Illinois Pollution Control Board, a sister Agency to the Illinois EPA, promulgates water quality standards in Illinois. Two sections of 35 Illinois Administrative Code (IAC) are relevant, which are Section 302 Water Quality Standards and Section 303. Derived water quality criteria are available from the State of Illinois (Link).

6.4.1 Mississippi River

Most of the water quality monitoring information available for this portion of the Mississippi River appears to be limited to isolated samples collected by the EPA. For an evaluation of water quality conditions on the Mississippi River, one would need to review more comprehensive, long-term water quality monitoring datasets, such as those found at several monitoring sites found farther upstream of Refuge properties. However, upstream monitoring sites will not reflect any potential contamination occurring between the site and the Refuge and therefore were not listed in this inventory.

6.4.2 Edwards River and Pope Creek

In 2009, the typical fish species near the Keithsburg Division on the Edwards River were spotfin shiner, gizzard shad, rosyface shiner, channel catfish and carp. A review of recent water quality sampling by the Illinois EPA showed high levels of phosphorous at the site. Older sampling (late 1990s) by the USGS had significantly elevated nutrients at the site.

Pope Creek was sampled upstream of Keithsburg, IL by the IEPA for fish in 1999 and 2004 (Link). Bluntnose minnow was the most common species based on abundance for both samplings. Generally, species abundance was greater during the 2004 sampling, which found small numbers of additional species not found in 1999 (warmouth, walleye, gizzard shad, flathead catfish). Other typical species included: Golden redhorse, carp, bluegill and a variety of shiner species. The lower reach of Pope Creek was assessed for support of aquatic life and was determined to be good.

6.4.3 The Iowa River at Wapello water quality

The Iowa River at Wapello (USGS 05455500, Link) gage contains multiple in situ water quality sensors (i.e. turbidity and NO_3/NO_2) and is regularly sampled for a number of water chemistry parameters. This site was a synoptic large river site, as part the U.S. Geological Survey's National Water-Quality Assessment Program study of Eastern Iowa Basins, to assess the occurrence, distribution, and transport of nitrogen, phosphorus, suspended sediment, and organic carbon (USGS 1999, 2001, 2003). The gage is also part of the USGS National Streamflow Information Program, which suggests funding for the gage will be maintained, and water quality sampling will be regular.

Water samples from the Iowa River indicate high loads of suspended sediments, nutrients and bacteria. Nitrogen loads in the Iowa River are some of the highest in the Corn Belt (as well as the nation). Nitrate concentrations were higher than the drinking water standard (>10 mg/l) in many samples. These conditions reflect the intensive use of the land for growing crops and dense populations of livestock in some basins. Nitrogen was high in the early spring (May-June), when stream discharge is a greater proportion than groundwater.

6.4.4 Contaminants Assessment Process (CAP)

This process included the identification of contaminant sources that are on and off the Refuge units, delineation of transport pathways for contaminants, potentially contaminated areas, and natural resources at risk. The major hydrologically relevant conclusions by Coffey et al. (2012) within the CAP are:

1. The Upper Mississippi River basin is considered a major source of nutrients (especially nitrate) that contribute to the Gulf dead zone or hypoxia problem (Rabalais, Turner, & Scavia, 2002). The water sources for the Mississippi River include the tributary rivers, drainage ditches, tile drainage systems, and groundwater. These water sources load the backwaters of the Iowa River and Mississippi River with nutrients.

2. The Upper Mississippi River also transports the cumulative load of chemicals that pass through wastewater treatment plants such as pharmaceuticals, household chemicals and synthetic chemicals used for fabrics or containers (Wiener & Sandheinrich, 2010). These chemicals are collectively known as contaminants of emerging concern or emerging contaminants. Many of the emerging contaminants are hormone disruptors that have induced inter-gender fish in North American rivers.

3. Research conducted by the USFWS in the late 1990s indicated that the surface water inputs at Keithsburg Division have elevated nutrient concentrations and the sediments have elevated organic content, nutrients, and slightly elevated copper (USFWS 1998). The nutrients are believed to be from inputs along transport pathways and the loading of the sediments by organic matter from high phytoplankton and macrophyte production. The organic matter decays and creates ammonia, which is converted to other forms of nitrogen, including nitrate.

4. Studies conducted by the U.S. Geological Survey (USGS) in the Upper Mississippi River and the Iowa River indicate that these waterways transport high loads of suspended sediments, nutrients, and pesticides (USGS, 1995; USGS, 2001; USGS, 2003). The sources of the nutrients are municipal and industrial wastewater discharges and agricultural run-off and tile drainage systems. The sources of sediments are upland crop field runoff and erosion of riverbanks throughout the watershed. The sources of pesticides are upland crop run-off and leaching. Sediments from upland sources may have pesticides, phosphorus, and ammonia bound to the particles. Other nutrients, such as nitrate and some phosphates, dissolve in the water.

5. Dredging projects and associated research by the U.S. Army Corps of Engineers (USACE) for HREPs at both the Big Timber Division and Louisa Division illustrate sedimentation problems.

6.4.5 303(b) reporting, 303(d) assessments and Category 4c

Section 303(d) of the Clean Water Act requires that each state identify water bodies where water quality standards are not met based on designated usage. Impairment in the Mississippi River can be determined by either state. There are no impaired water listings under Section 303(d) of the Clean Water Act within the Refuge units. However, these waterways have not necessarily been assessed, which means the lack of an "impaired" designation does not preclude issues of concern. Small ditches and wetlands do not have well defined standards and are not typically assessed by state organizations. There are no fish consumption advisories within the Refuge units. However, there are five impaired water listings for waters relevant to the Refuge Divisions:

- The Mississippi River from Burlington, IA to the confluence with the Iowa River does not support aquatic life use due to violations of state water quality criteria for aluminum and cadmium. Drinking water use is not supported due to violations of state criteria for arsenic. Fish consumption uses remain “not assessed,” due to the lack of recent fish contaminant monitoring in this river segment. The source of data for this assessment is the monitoring conducted from May 8, 2008 to November 16, 2010 by the Illinois Environmental Protection Agency at station L-04 at Lock & Dam 17 near New Boston, IL (river mile 437).

- The Mississippi River south of the confluence with the Iowa River and adjacent to the Keithsburg Division does not fully support fish consumption due to mercury and PCB concentrations in fish tissues. The mercury in the Mississippi River is likely from atmospheric deposition of industrial air emissions around the Midwest and Eastern United States. PCB sources include historic industrial wastewater discharges into the Upper Mississippi River. This part of the Mississippi River does not support primary contact for recreation because of fecal coliform and does not support water supply usage due to elevated manganese.

- The lower reach (≈14.3 miles) of the Edwards River, which flows into Keithsburg Division over a spillway during flood stages, does not support primary contact use due to elevated fecal coliform bacteria counts, but was determined to be sufficient to support aquatic life. The fecal coliform may be from permitted municipal wastewater discharges and runoff from livestock feed lots or sewage sludge applications to crop fields as fertilizer. It is possible this issue is only intermittent or has been mitigated at this point.

- The Edwards River near Orion, IL (upstream of Keithsburg) is part of the Illinois Category 4C list (≈31.19 miles reach), which identifies impairments not caused by pollutants. The identified cause of a “lack of support of aquatic life” is “alteration in stream-side or littoral vegetative covers” and “loss of in-stream cover”. This type of finding suggests that very little riparian habitat or buffering remains on this stretch.

Additional information of the status of assessments and the delisting of streams is available from Illinois EPA (Link) and Iowa DNR (Link).

Table 4 Water quality, stream stage, and climate monitoring sites (inactive and active)

Site Name	ID (Link)	Alternate ID (Link)	Responsible Organization(s)	Data Availble	Comments	HUC	Applicable Division(s)	Within Division?	Start date	End date
Flaming Prairie Park	USGS 411540091064201	N/A	USGS	Groundwater elevation	Water surface level ranged from 4 to 0 ft. below ground surface	7080101	Big Timber (north island)	Yes	7/1/1992	7/1/1994
Mississippi: Lower Impounded	GRW04449-284	N/A	EPA-Great River Ecosystem program	Single sampling event w/ comprehensive dataset	U/S of Iowa River and Mississippi River confluence; EMAP_GRE site. This site includes the collection of numerous habitat indices and parameters.	7080101	Louisa	No	9/10/2004	9/10/2004
Lake Odessa	IA_01-NEM-00105-L_0	IADNR data	Iowa Department of Natural Resources	Basic water quality parameters and some chemistry	Water chemistry ratio of TN:TP suggests that nitrogen may be limiting. In 2006 and 2007 the measured ratio (TN:TP) were 5 and 7 respectively	7080101	Louisa	Yes	6/6/2006	8/6/2007
Groundwater site-north Keithsburg, IL, within Pope Creek drainage area	USGS 410605090555102	N/A	USGS	Groundwater elevation, water chemistry	Samples were collected at number of wells within Mercer County in 1986. Water quality was excellent.	7080104	Keithsburg	No	8/22/1986	
Edwards River near New Boston, IL	USGS 05466500	IL_EPA-LF-01	USGS, Illinois Department of Natural Resources, USACE,Illinois EPA	Stage, discharge, metals, nutrients and some pesticides. Precipitation (limited; USCE-411113090580200)	Most applicable station for determining flooding at Keithsburg. Extensive chemistry sampling from 1979 -1997 and 2003-2005. Limited sampling from 2004 to 2011	7080104	Keithsburg	No	8/1/1963	
Edwards River upstream of New Boston	IL_EPA_WQX_LF-05	N/A	Illinois Department of Natural Resources, Illinois EPA	Metals, nutrients and some pesticides	Intermittent sampling from 2004 to 2011	7080104	Keithsburg	No	6/1/2004	
Edwards River near Orion, IL	USGS 05466000	L_EPA_WQX_LF-08	USGS, Illinois Department of Natural Resources, Illinois EPA	Stage, discharge, metals, nutrients and some pesticides	Comprehensive sampling monthly 06/2004-10/2004 and intermittent sampling into 2009	7080104	Keithsburg	No	10/1/1940	

Pope Creek near Keithsburg, IL	USGS 05467000	N/A	USGS, Illinois Department of Natural Resources, Illinois EPA	Stage, discharge and some water chemistry	Minimal water chemistry data. Applicable for determining flooding at Keithsburg.	7080104	Keithsburg	No	10/1/1934	
Pope Creek (upstream)	IL_EPA-LE-03	N/A	Illinois Department of Natural Resources, Illinois EPA	Metals, nutrients, fish, pesticides and habitat	Extensive sampling in 2004. Additional sampling data from 1999 and 2009	7080104	Keithsburg	No	8/11/1999	
Mississippi: Lower Impounded	GRW04449-339	N/A	EPA-Great River Ecosystem program	Single sampling event w/ comprehensive dataset	U/S of Keithsburg and Edwards River; EMAP_GRE site	7080104	Keithsburg	No	7/19/2005	7/19/2005
Rain gage at Pope Creek near Keithsburg, IL	USCE-410744090550900	N	USGS and USACE	Precipitation (in.)	This site only displays the most recent 120 day, undergoes irregular calibration and has limited QA/QC. Useful for determing recent rainfall at the Keithburg location	7080104	Keithsburg	No	7/11/2013	
Cedar River near Conesville, IA	USGS 05465000	21IOWA-10700001; IASNAPST-970091	USGS<Iowa Department of Natural Resources	Stage, discharge and comprehensive water quality	There is a comprehensive set of data stored in multiple locations, primarily 1996-2012	7080206	Horseshoe Bend	No	9/16/1939	
Iowa River east of Wapello	1117MBR-006490	N/A	EPA- Region 7	fish length/weight, pesticides, heavy metals and DDT	3 sampling events, similar data to the gage location at Wapello	7080209	Horseshoe Bend	No	9/10/1997	9/5/2001
Iowa River at Oakville, IA	USGS 05465700	National Weather Service (forcast)	USGS-IA,U.S. Army Corps of Engineers - Rock Island District	Discharge, level and statistics	Drains 12,630 square miles. This gage is just downstream of Horseshoe Bend Division outlet	7080209	Horseshoe Bend	No	4/1/2009	
Iowa River at Wapello	USGS 05465500	National Weather Service (forcast)	USGS-IA, IA DNR	Discharge, level, temperature, suspended sediment, nitrate	Drains 12,500 square miles. This gage is upstream of Horseshoe Bend Division outlet	7080209	Horseshoe Bend	No	10/1/1914	
Mississippi: Lower Impounded	GRE06604-1020	N/A	EPA-Great River Ecosystem program	Single sampling event w/ comprehensive dataset	U/S of L&D 17, within pool 17; EMAP_GRE site. This site includes the collection of numerous habitat indices and parameters.	7080209	Louisa	No	7/13/2006	7/13/2006

Rain gage at Mississippi River at New Boston, IL	USACE 411130091032900	N/A	U.S. Army Corp of Engineers	Precipitation (in.)	This site is loccated at the Pool 17 Lock&Dam	7080209	Louisa	No	6/2/2013	
Mississippi Pool 17 L&D	USACE_gage	N/A	U.S. Army Corp of Engineers	Stage (ft.) for Pool 17 and tailwater release from dam	This site is loccated at the Pool 17 Lock&Dam	Multiple	Louisa, Big Timber and Horseshoe Bend	No	~1900	
Mississippi River at Keithsburg, IL	USACE_gage	N/A	U.S. Army Corp of Engineers	Stage (ft.)	Located on the river left side, just south of the Keithsburg Division	7080104	Keithsburg	No	~1900	
Inactive and indirectly relevant sites										
Groundwater site in Oakville, IA	USGS 41055709102370	N/A	USGS	Water quality	6 Sampling events for a large variety of paramaters. Heavy metals, nutrients, pesticides and other contaminants	7080104	Horseshoe Bend	No	7/15/1974	8/13/1987
Groundwater site near Toolesboro, IA	USGS 410557091023701	N/A	USGS	Water quality	1 Sampling events for a large variety of paramaters. Data suggests a significant surface water contamination at the time (e.g. 9/1967)	7080209	Horseshoe Bend	No	9/6/1967	9/6/1967
Groundwater site on the northern side of Rush Lake	USGS 410819091053801	N/A	USGS	Water quality and level	1 Sampling events for a variety of paramaters. Depth to water was 85 ft. in 1943 and 1944	7080209	Horseshoe Bend	No	3/17/1943	8/18/1944
Groundwater site	USGS 410750091060301	N/A	USGS	Water quality	1 sampling event in 1944, which indicated extremely elevated levels of contamination. Although, data appears anomalous	7080209	Horseshoe Bend	Yes	8/18/1944	8/18/1944
Otter Creek near Wapello	USGS 05465600	N/A	USGS	Discharge	Low water discharge measurements	7080209	Horseshoe Bend	No	9/24/1957	9/8/1976
Groundwater site near Lake Odessa	USGS 411156091070201	N/A	USGS	Water level/Water Quality	1 measurement	7080101	Louisa	No	9/6/1967	9/6/1967
North Fork Long Creek at Ainsworth, IA	USGS 05465150	N/A	USGS	Peak streamflow only	Active data collection. Location only useful for evaluating regional trends	7080209	Horseshoe Bend	No	8/25/1955	Active

7 Water Law

Applicable water law was summarized for Region 3 by the DOI solicitor's office below:

> *The Refuge Divisions are located in both Iowa and Illinois, which means subtle differences in applicable water law do exist, despite a common basis in riparian right doctrine. In states that apply the riparian rights doctrine, landowners of property with naturally flowing surface water running through or adjacent to their property have rights to reasonable use of the surface water associated with the property itself. The "reasonable use" standard protects downstream users by ensuring that one landowner's use does not unreasonably impair the equal riparian rights of others along the same watercourse. Additionally, the law limits riparian rights to those rights "intimately associated" with the water; uses falling outside of this definition are usually considered unreasonable uses.*[1]
>
> *An important corollary to the riparian rights doctrine is that, generally, states classify their navigable*[2] *surface waters as public, whether through statute or through the common law public trust doctrine.*[3] *This is important because on public waters, the riparian landowners' rights are subject to public rights of, at a minimum, navigation. For this reason, states regulate waters for the purpose of putting the water to "beneficial use," a term defined differently amongst the states.*

7.1 Iowa

For additional information on water quality standards (Chapter 61 of the Iowa Administrative Code) and permitting, the IDNR is the primary contact and regulatory authority (Link). Construction, excavation or filling in streams, lakes, wetlands, or on the flood plains may require permits from both the U.S. Army Corps and Iowa DNR. A joint application form should be submitted to both agencies to begin the permit process for any of the following activities according to the IDNR (Link):

- *Cutting the bank of a river, stream, or lake*
- *Any excavation or dredging in a wetland, lake, stream or river*
- *Channel changes or relocations (including stream straightening)*
- *Construction of any permanent dock, pier, wharf, seawall, boat ramp, beach, intake or outfall structure on a stream, river or lake*
- *Placement of any fill, riprap, or similar material in a stream, river, lake, or wetland*
- *Construction of a dam across any waterway*
- *Placement of fill, construction of levees, roadways and bridges; and similar activities on a floodplain; or construction of buildings on a flood plain*
- *Any construction on, above, or under all fee title lands and waters, dedicated lands and waters under the jurisdiction of the Natural Resource Commission (Commission) and managed by the Commission for public access to a meandered sovereign lake or meandered sovereign river and sovereign islands (except those portions of the Iowa River and Mississippi River where title has been conveyed to Charter Cities).*

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[1] *John W. Johnson, United States Water Law: An Introduction 38 (CRC Press, 2009).*
[2] *"Navigable," in this context, is a legal term of art that varies from state to state, separating public waters from those that are private. As a general notion, "navigable" means navigable in fact, which, historically, has been tested by whether or not a log or canoe could float on the water. See, e.g., Paul G. Kent & Tamara A. Dudiak, Wisconsin Water Law: A Guide to Water Rights and Regulations 4 (University of Wisconsin-Extension, 2d ed., 2001).*
[3] *The public trust doctrine, in most states, refers to the concept that state, as trustee to the public, preserves navigable waters "for public use in navigation, fishing and recreation." Black's Law Dictionary 1232 (6th ed. 1990). This prohibits the state from selling the beds to private parties.*

From the DOI Solicitor office:

> *Like other states in the region, Iowa's stated water policy is to conserve and protect water resources by putting all water to beneficial use, and preventing unreasonable use. The state defines "beneficial use" as one that applies water "to a useful purpose that inures to the benefit of the water user and subject to the user's dominion and control but does not include the waste or pollution of water." While courts have not explicitly announced whether this definition includes instream uses for fish and wildlife, as a refuge manager, FWS certainly puts instream uses to a useful purpose directly associated with the benefits FWS seeks to reap. In order to accomplish this policy, the state gave the authority and duty to the Iowa Department of Natural Resources (DNR) to assess the water needs and prepare a water allocation plan.*
>
> ***Iowa uses a regulated riparian approach by enacting a permit system for "depleting uses," which include diversion, storage, and withdrawal. This permit system applies to public waters, or waters occurring in a "basin" (i.e., aquifers) or "watercourse" (i.e., surface water), and storage and withdrawals from groundwater aquifers. Persons, including federal government agencies, using more than 25,000 gallons-per-day must have a permit; any amount below this the state classifies as a "non-regulated use."*** *DNR issues permits so long as the "established average minimum flow is preserved," and denies permits for uses that will impair: (1) the effect of pollution control laws, (2) navigability of a watercourse, (3) long-term availability of surface or groundwater, or (4) public health or welfare. The permits only last for either ten or twenty-five years depending on the type of permit, and based on the criteria above, DNR may also limit the quantity and time period when withdrawals can be made. Upon receipt of a citizen complaint, DNR will investigate unauthorized withdrawals of a depleting use.*
>
> *The Iowa Environmental Protection Commission (EPC) determines the average minimum flow (also called "protected flow" in the state's regulations) of the watercourse for which a water user has submitted a permit, and the measurement should be based on the "limit at which further withdrawals would be harmful to the public interest," among other factors. EPC promulgated regulations that include the specific protected flow for numerous rivers, and branches thereof, throughout the state. If a gage located at one of the listed rivers or streams measures flow levels below those in the regulations, then consumptive uses (excepting public water supply consumption) on the river will cease. Although permits do not establish priority at the time of issuance, the state may, if triggering events occur, "suspend or restrict" both permitted depleting uses and non-regulated uses by implementing a "priority allocation plan." Essentially, these triggering events identify situations when water shortages might occur, and provide four means of notifying DNR that a drought or emergency affecting water resources is imminent. Once a triggering event occurs, then DNR restricts water based on the type of use beginning with the lowest water priority, "water conveyed across state boundaries," up to the highest priority, private waters for human consumption. While the priority allocation plan does not list use of water for wildlife purposes, the plan restricts "uses of water for recreational or aesthetic purposes" second in its reverse-priority list, after water conveyed across state lines. Given that recreational and aesthetic purposes also rely on instream flows, it is likely that wildlife purposes would also fall into this type of use, were DNR to implement its priority allocation plan.*
>
> *The state also provides for other permit or financing programs that may help to protect instream water resources. For example, the state requires permits for dams along its waters and allows local government units to plan for development on floodplains, which are then adopted by the states. It also created a sponsor program for water resource restoration, which provides funds to communities conducting watershed projects. The program specifically identifies projects like "instream habitat enhancements or dam removals," as desirable.*
>
> *By instituting a comprehensive priority-based permit program, Iowa has taken a significant role in protecting its water resources, and as a result the program will conserve instream flows that will help FWS. Even though the state does not provide FWS a means to insert itself into the permitting system, FWS will still have common law riparian rights that it may assert against other riparian right holders. Further, Iowa and FWS share the same goals of conserving instream water, as shown by its broad definition of beneficial use and the state's policy statements.*

7.2 Illinois

IDNR is the state agency with the most direct regulatory authority over wetlands in Illinois. The primary authority of this agency is established in the Interagency Wetlands Policy Act of 1989. This Act provides the Department with regulatory authority over state activities that affect wetlands. The Interagency Wetlands Policy Act established the goal of, "no overall net loss of the state's existing wetland acres or their functional values due to state supported activities." Illinois is the second state to adopt a "no net loss goal" in legislation with the passage of this Act. Additional regulatory authority is in the Rivers, Lakes, and Streams Act, which provides the Department with regulatory authority over activities in floodplains. The regulatory program requires permits for construction in the floodway of any stream serving a tributary area of 640 acres in urban areas, or 6,400 acres in rural areas. Information on permitting requirements is available from the IDNR (Link). Essentially, permits may be necessary for construction activities that discharge into wetlands and for dredge and fill activities in floodplains of waterways which contain catchments of greater than 6,400 acres. However, routine maintenance typical of agricultural activities is excluded from these requirements (i.e. ditch maintenance, tile installation, etc.).

The Illinois EPA is the agency responsible for reporting to the US EPA on the status of surface water and groundwater under Sections 305(b) and 303(d) of the Federal Clean Water Act (CWA). Additionally, the IL EPA is the permitting and enforcement authority for groundwater, drinking water, storm water runoff and pollution discharge permits. The Illinois EPA established the Groundwater Quality Standards (GWQS) (35.Ill.Adm.Code 620), detailed explanations and listings for which can be found through the Illinois Pollution Control Board's webpage (Link).

Additional info from the DOI Solicitor office:

> *Illinois does not have a sophisticated means for claiming rights to water, especially for instream water rights. As a state that generally follows the traditional riparian rights doctrine,[4] all landowners adjacent to a body of water have a right to reasonable use of the water, so long as it does not impact the same rights as other similarly situated landowners.[5] The legislature codified surface and ground water into one system under the Water Use Act of 1983, which extended the common law reasonable-use rule to groundwater withdrawals.[6]*
>
> *The statute specifically defined "reasonable use," in keeping with the common law, as "the use of water to meet natural wants and a fair share for artificial wants. It does not include water used wastefully or maliciously."[7] In Illinois, "natural wants" refer to uses necessary to the land, mainly domestic uses.[8] "Artificial wants," on the other hand, refer to uses that would increase "comfort and prosperity."[9] In times of shortage, the state will prioritize natural wants over artificial wants, and once natural wants are satisfied, water users may consume their "just proportion" of artificial wants.[10] Courts ultimately determine on a case-by-case basis whether a water user has consumed beyond his "just proportion," looking at the relative needs of the water users and the water availability.[11]*
>
> *With the reasonable-use rule as a foundation, Illinois allows communities to regulate groundwater consumption through the establishment of water authorities, in order to give communities the power to take control of their local resource. The*

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[4] *Evans v. Merriweather, 4 Ill. 491 (1842); Knaus v. Dennler, 525 N.E.2d 207, 209 (Ill. App. Ct. 1988).*
[5] *Gary R. Clark, Illinois Groundwater Law: The Rule of Reasonable Use 14–15 (State of Illinois, Department of Transportation and Division of Water Resources 1985).*
[6] *Water Use Act of 1983, 525 Ill. Comp. Stat. 45/6 (2011).*
[7] *525 Ill. Comp. Stat. 45/4.*
[8] *Evans v. Merriweather, 4 Ill. 491, 495 (1842).*
[9] *Id.*
[10] *Bliss v. Kennedy*, 43 Ill. 67, 74 (1867).
[11] *Id.* at 76–77.

Water Authority Act (WAA) sets out a detailed and extensive procedure for citizens to create a water authority, but once established, the local authority has broad powers.[12]

At least thirteen water authorities have been established since the law was enacted, mostly in the eastern-central part of the state.[13] *However, the WAA specifically excludes water used for agricultural purposes, irrigation, and small domestic wells for less than four families from the Authorities jurisdiction.*[14] *The law does not provide any specific authority for water authorities to ensure minimum flows or instream uses, but at least provides a broad catchall, allowing authorities to "make such regulations as it deems necessary to protect public health, welfare and safety and to prevent pollution of its water supply."*[15] *This may be the only provision FWS could rely upon to protect instream flows within a local water authority region.*

In addition to the local water authorities, the Illinois Department of Natural Resources (DNR) has jurisdiction over public waters, and the agency has a duty to document all navigable waters and "jealously guard the true and natural conditions" of state waters.[16] *Under this policy, DNR's Office of Water Resources manages a permit system for construction projects in public water ways, i.e. navigable waters, and for public water developments that may impact public rights to use the water.*[17]

In Illinois, FWS has a right to the reasonable use of surface and ground water associated with the boundaries of the refuges. While FWS cannot affirmatively assert its right to instream use, it may have a claim against other water users if a shortage occurs, even if that right consists of a just proportion of its natural wants.[18] *However, these issues have yet to be explored by the courts.*

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12 70 Ill. Comp. Stat. 3715/1 *et seq.* (2011).
13 *See* http://www.isws.illinois.edu/docs/wsfaq/wsmore.asp?id=q6; http://www.agr.state.il.us/marketing/IALD/organizations/IALDDirectory%2058.pdf.
14 70 Ill. Comp. Stat. 3715/8 (2011).
15 70 Ill. Comp. Stat. 3715/24 (2011).
16 615 Ill. Comp. Stat. 5/5 (2011).
17 Ill. Admin. Code tit. 17 §§ 3700, 3704, 3708 (2010).
18 Illinois courts have not spoken on whether instream uses for fish and wildlife purposes would constitute a natural want.

8 Geospatial Data Sources

Many of the GIS layers are available from the Iowa Geographic Map Server hosted by Iowa State University: http://ortho.gis.iastate.edu/. This site contains multiple years (30s, 50s, 60s, 90s) of aerial imagery, color infrared Digital Orthophotos Quads, 2002-landcover map from the Iowa Geological Survey Bureau, Iowa historic vegetation map from General Land Office surveyor records of 1832-1859 and other applicable layers.

Mississippi River information and GIS layers for Pool 17 are available from the USGS Upper Midwest Environmental Science office (http://www.umesc.usgs.gov/umesc_home.html).

LiDAR data was produced by the Iowa Lidar Consortium and available for the Divisions from the Iowa LiDAR Mapping Project (http://geotree2.geog.uni.edu/lidar/). LiDAR data for Mercer County was received by request from the Illinois State Geological Survey

Background aerials are from the U.S. Department of Agriculture National Agriculture Imagery Program (NAIP)

The National Hydrologic Dataset (NHD) is produced as a cooperative effort by the Environmental Protection Agency (EPA), The U.S. Geological Survey (USGS), other federal agencies and state agencies.

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10 Appendix A Historical map of Louisa County

Figure 21 Image of map of Louisa County, State of Iowa (1875) by Andreas, A.T. Published by Adreas Atlas Co., Chicago, IL Available from the David Rumsey Historical Map Collection

11 Appendix B Topographic image for PLONWR

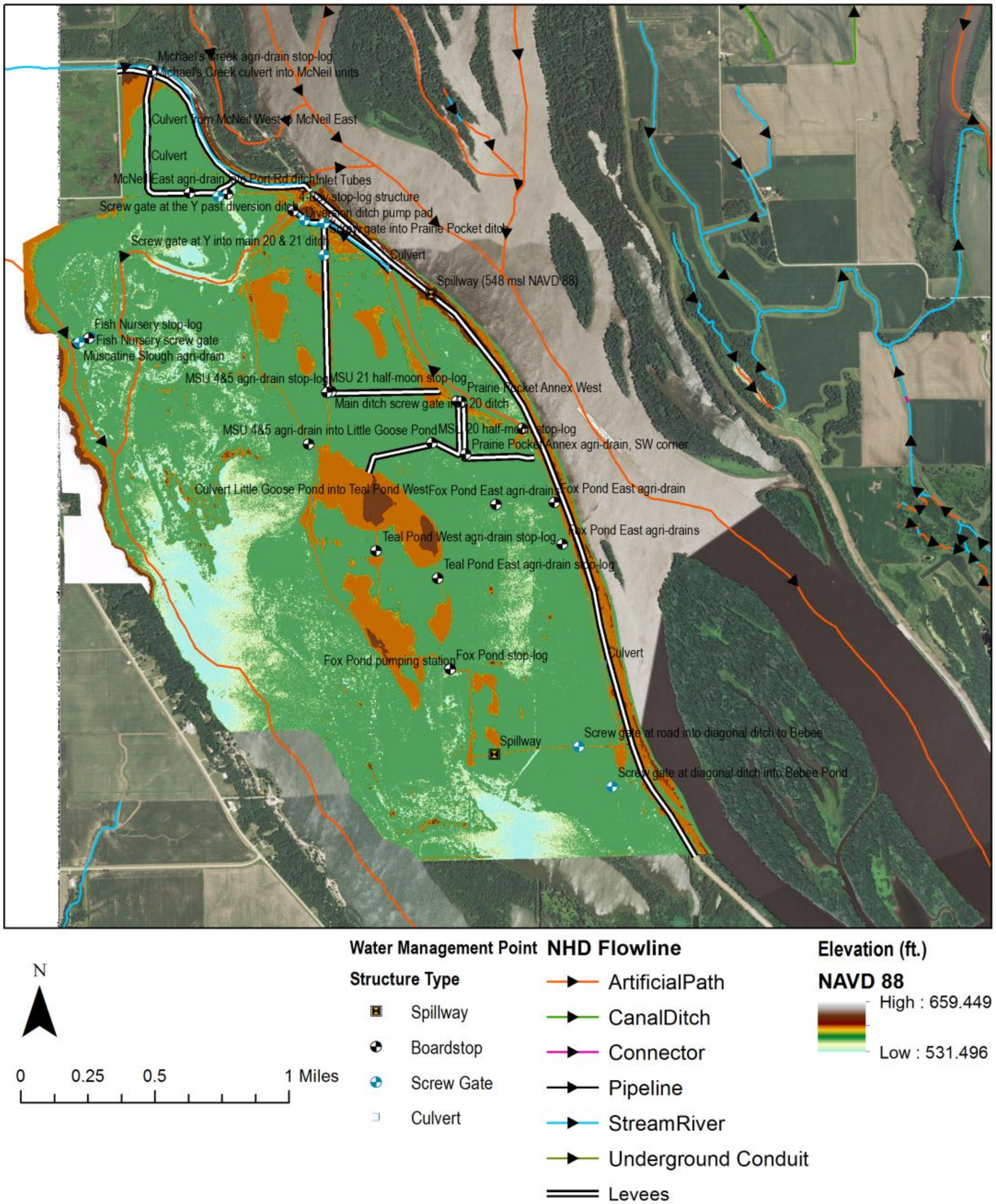
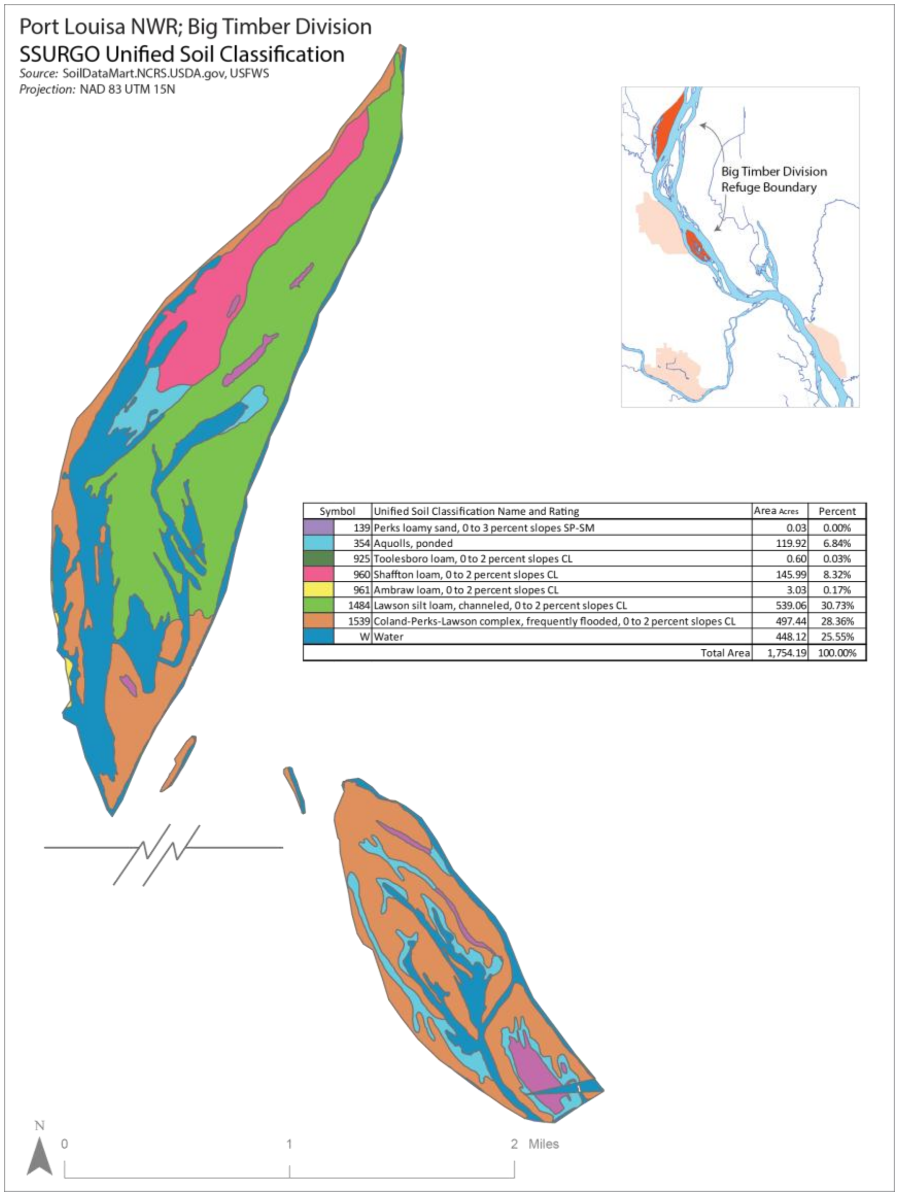


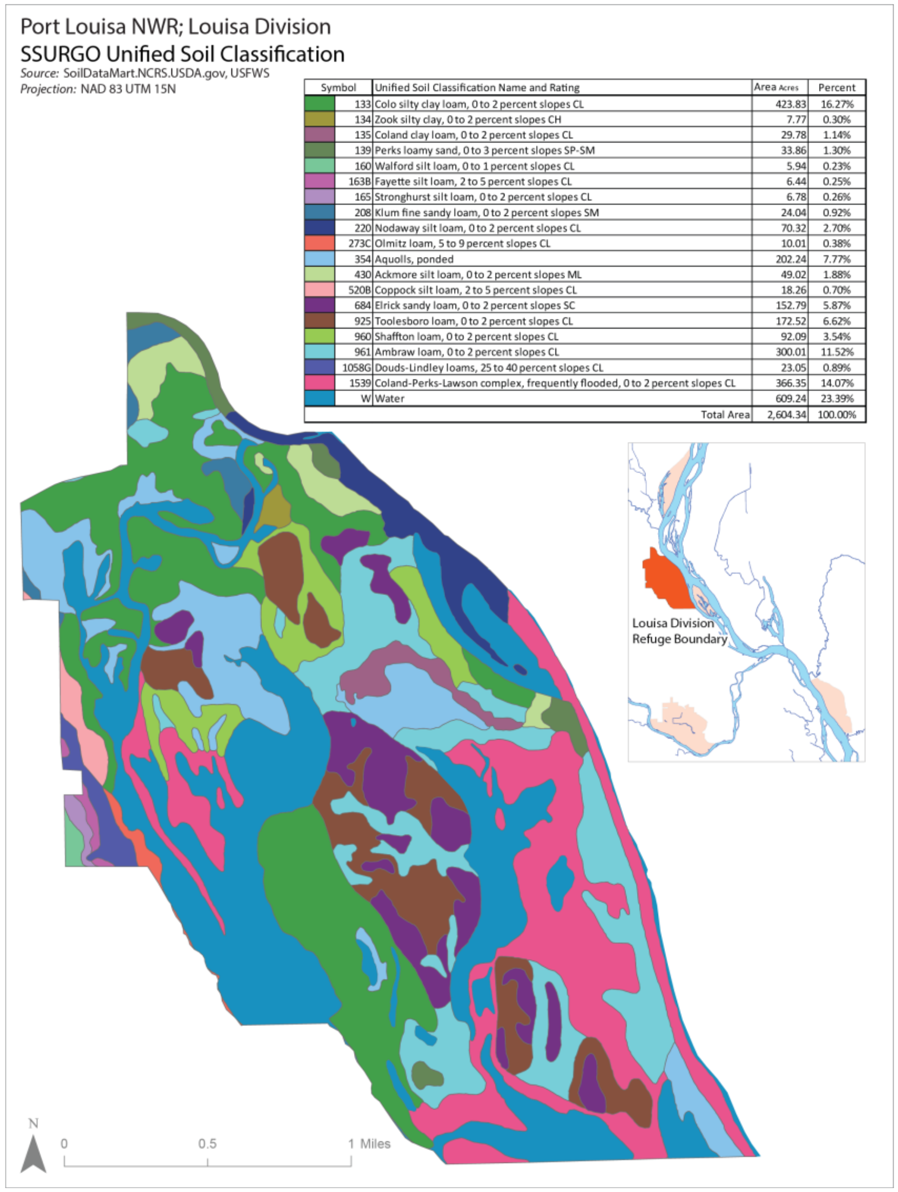
Figure 22 Water control structures and NHD flowlines for Louisa Division

12 Appendix C SSURGO soil classification and drainage type derived from soil classifications



Symbol	Unified Soil Classification Name and Rating	Area Acres	Percent
139	Perks loamy sand, 0 to 3 percent slopes SP-SM	0.03	0.00%
354	Aquolls, ponded	119.92	6.84%
925	Toolesboro loam, 0 to 2 percent slopes CL	0.60	0.03%
960	Shaffton loam, 0 to 2 percent slopes CL	145.99	8.32%
961	Ambraw loam, 0 to 2 percent slopes CL	3.03	0.17%
1484	Lawson silt loam, channeled, 0 to 2 percent slopes CL	539.06	30.73%
1539	Coland-Perks-Lawson complex, frequently flooded, 0 to 2 percent slopes CL	497.44	28.36%
W	Water	448.12	25.55%
	Total Area	1,754.19	100.00%

Figure 23 SSURGO soil database classifications for Big Timber Division



Symbol	Unified Soil Classification Name and Rating	Area Acres	Percent
133	Colo silty clay loam, 0 to 2 percent slopes CL	423.83	16.27%
134	Zook silty clay, 0 to 2 percent slopes CH	7.77	0.30%
135	Coland clay loam, 0 to 2 percent slopes CL	29.78	1.14%
139	Perks loamy sand, 0 to 3 percent slopes SP-SM	33.86	1.30%
160	Walford silt loam, 0 to 1 percent slopes CL	5.94	0.23%
163B	Fayette silt loam, 2 to 5 percent slopes CL	6.44	0.25%
165	Stronghurst silt loam, 0 to 2 percent slopes CL	6.78	0.26%
208	Klum fine sandy loam, 0 to 2 percent slopes SM	24.04	0.92%
220	Nodaway silt loam, 0 to 2 percent slopes CL	70.32	2.70%
273C	Olmitz loam, 5 to 9 percent slopes CL	10.01	0.38%
354	Aquolls, ponded	202.24	7.77%
430	Ackmore silt loam, 0 to 2 percent slopes ML	49.02	1.88%
520B	Coppock silt loam, 2 to 5 percent slopes CL	18.26	0.70%
684	Elrick sandy loam, 0 to 2 percent slopes SC	152.79	5.87%
925	Toolesboro loam, 0 to 2 percent slopes CL	172.52	6.62%
960	Shaffton loam, 0 to 2 percent slopes CL	92.09	3.54%
961	Ambraw loam, 0 to 2 percent slopes CL	300.01	11.52%
1058G	Douds-Lindley loams, 25 to 40 percent slopes CL	23.05	0.89%
1539	Coland-Perks-Lawson complex, frequently flooded, 0 to 2 percent slopes CL	366.35	14.07%
W	Water	609.24	23.39%
	Total Area	2,604.34	100.00%

Figure 24 SSURGO soil database classifications for Louisa Division

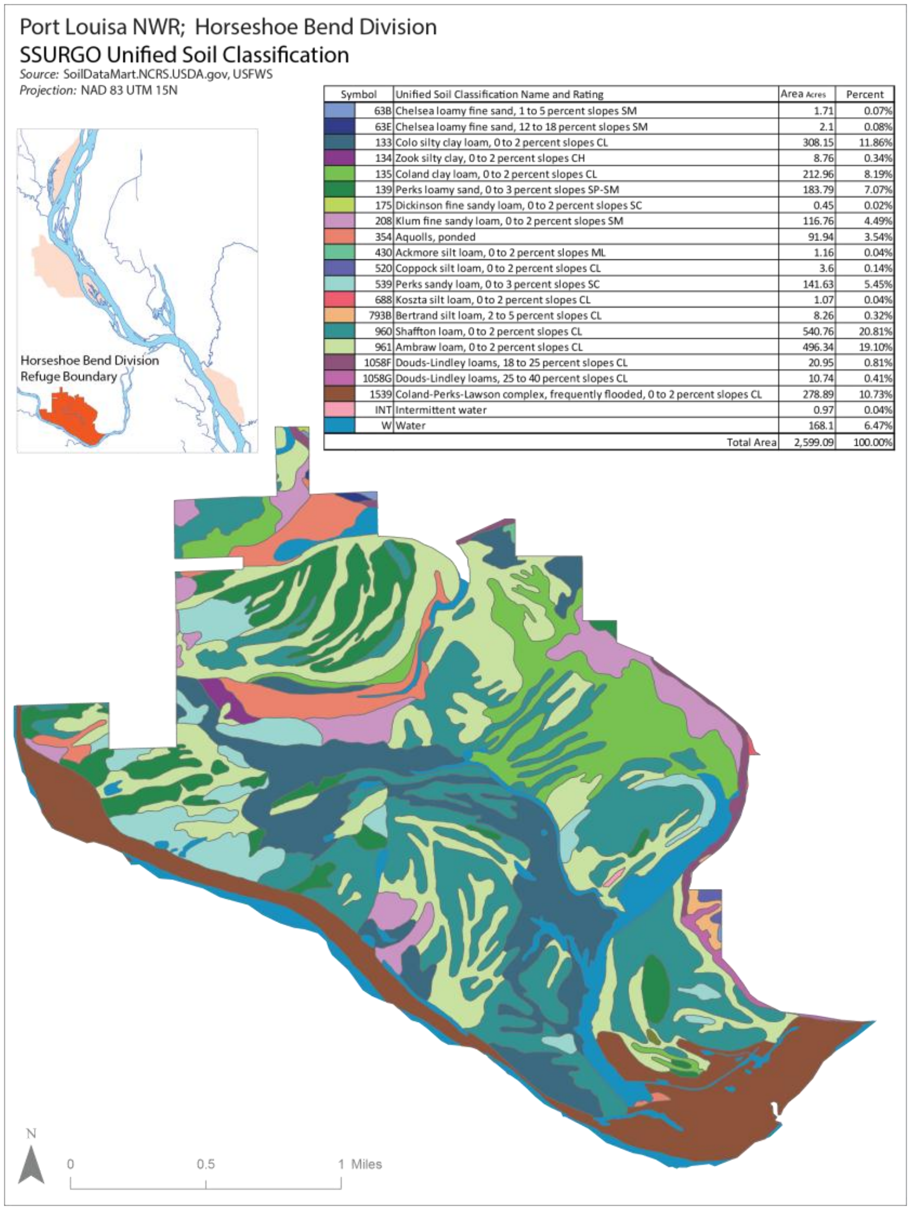


Figure 25 SSURGO soil database classifications for Horseshoe Bend Division

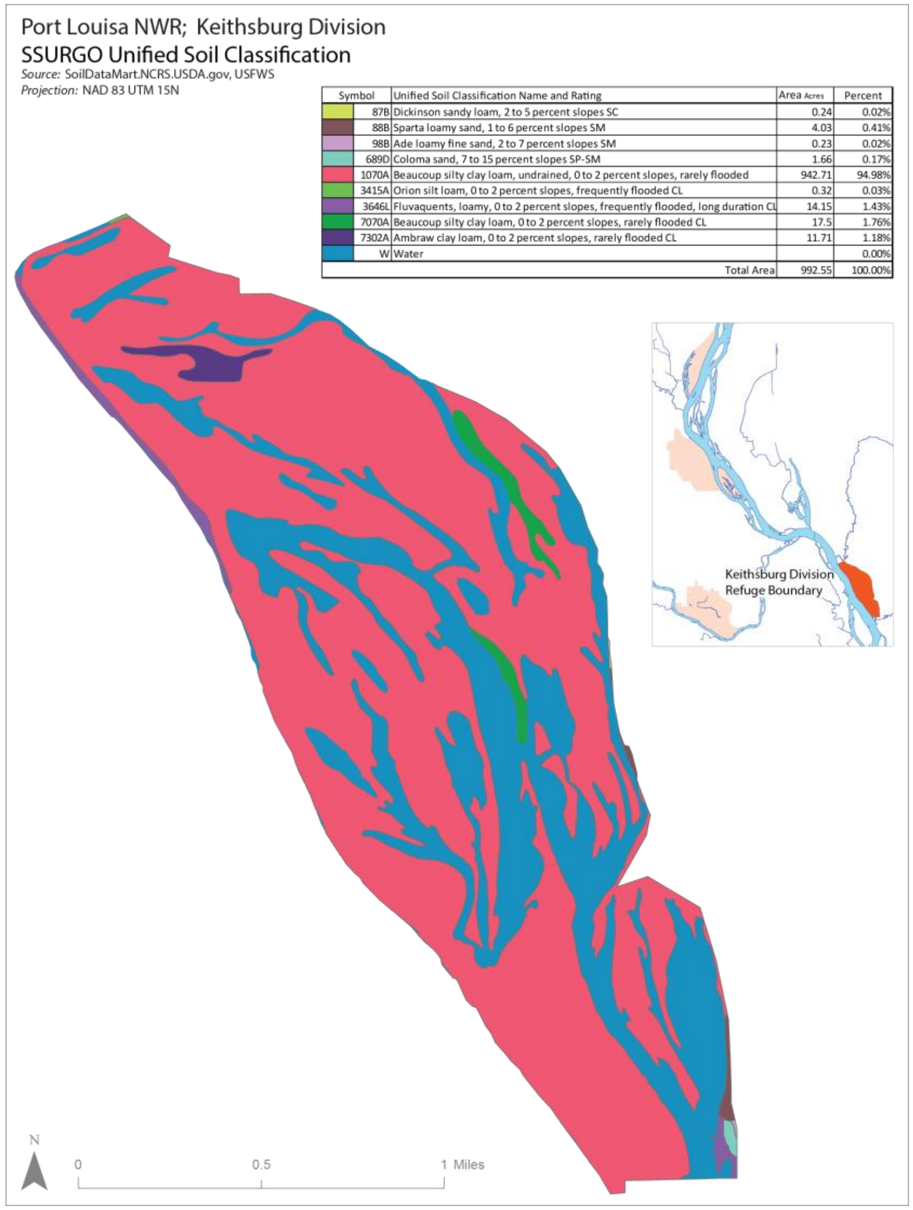


Figure 26 SSURGO soil database classifications for Keithsburg Division

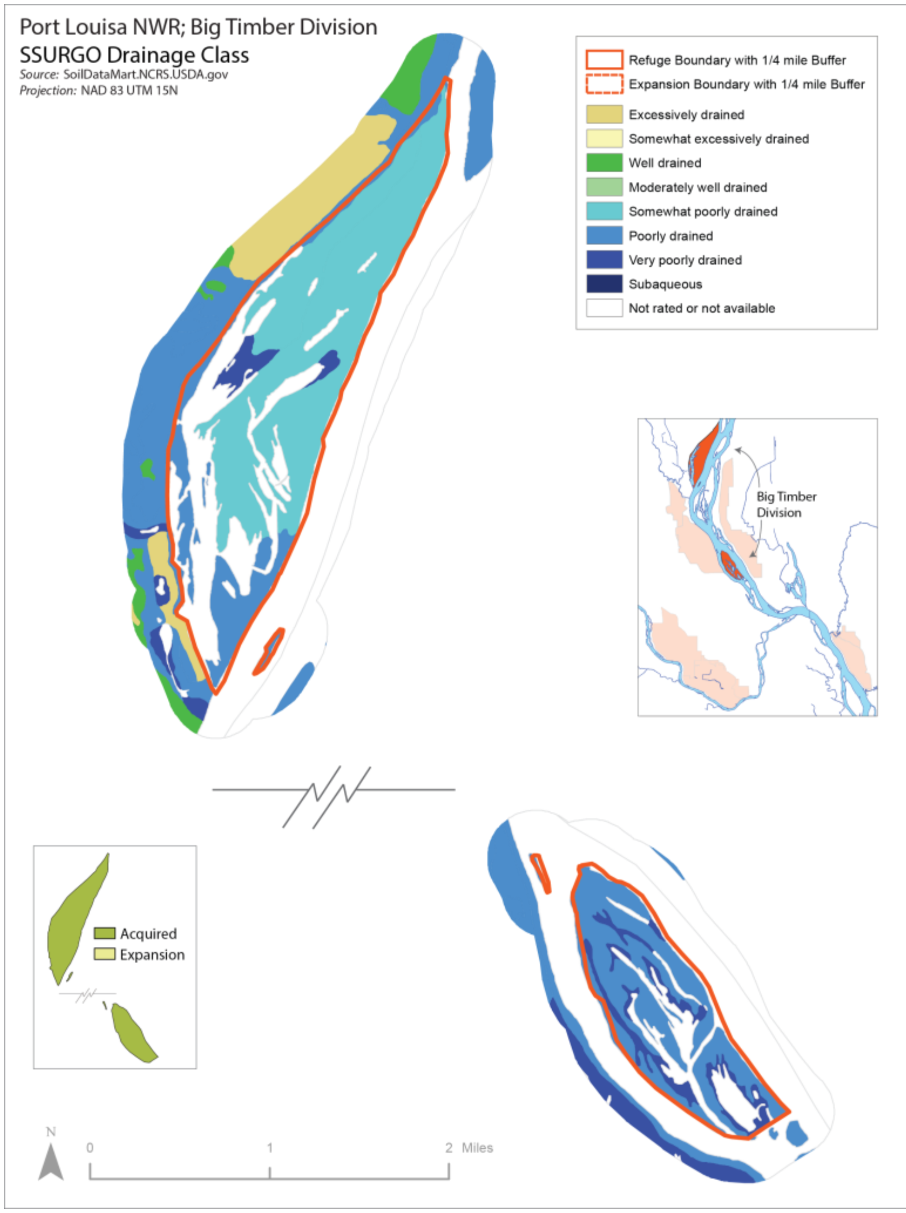


Figure 27 SSURGO soil database drainage classes for Big Timber Division

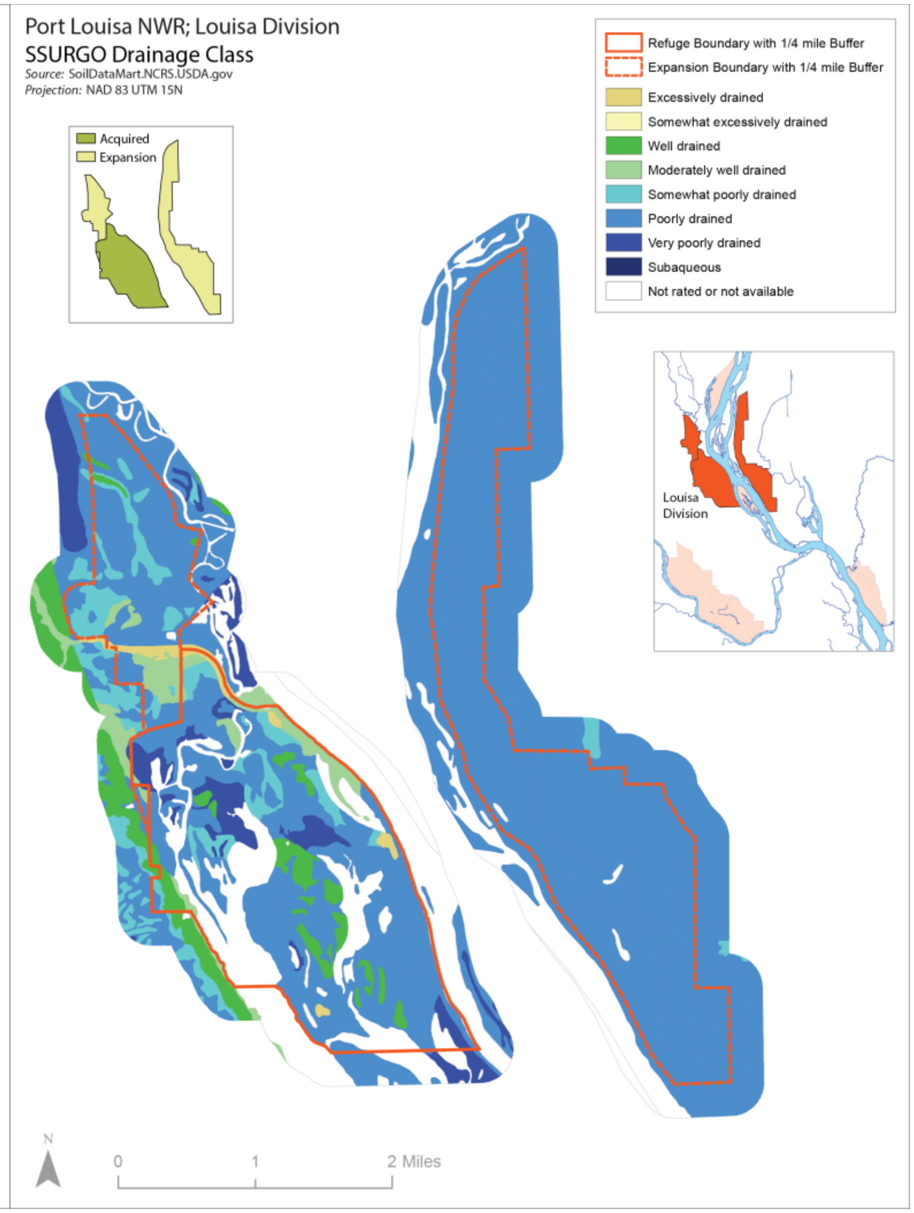


Figure 28 SSURGO soil database drainage classes for Louisa Division

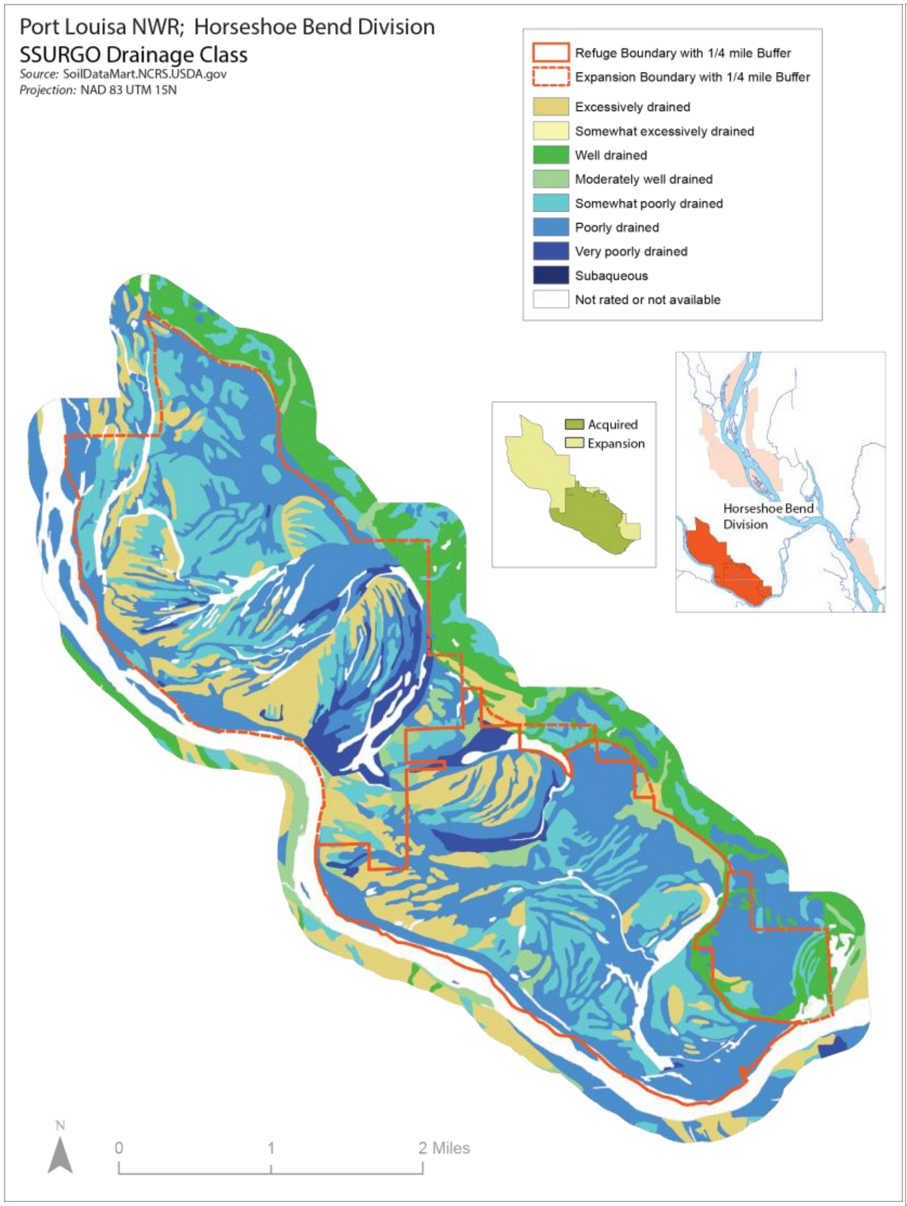


Figure 29 SSURGO soil database drainage classes for Horseshoe Bend Division

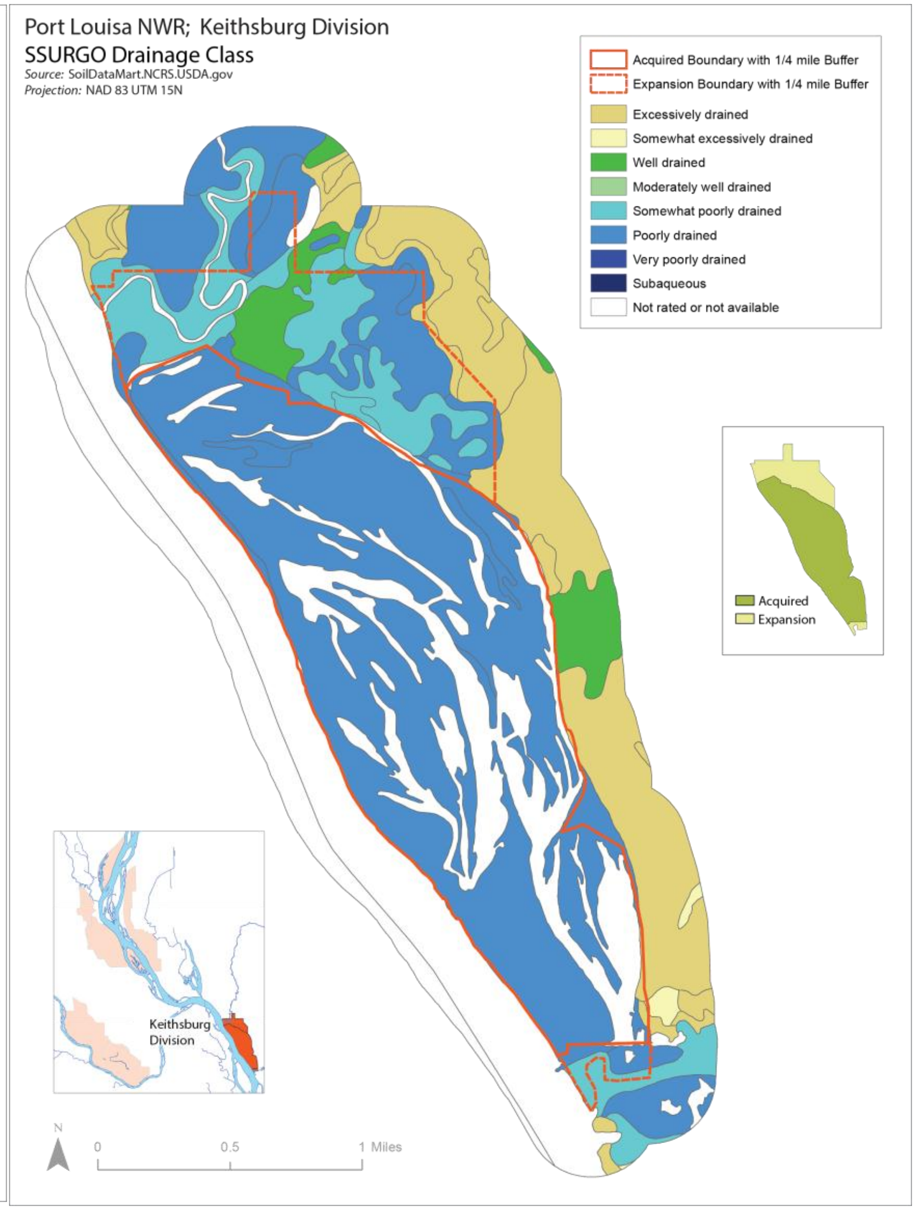
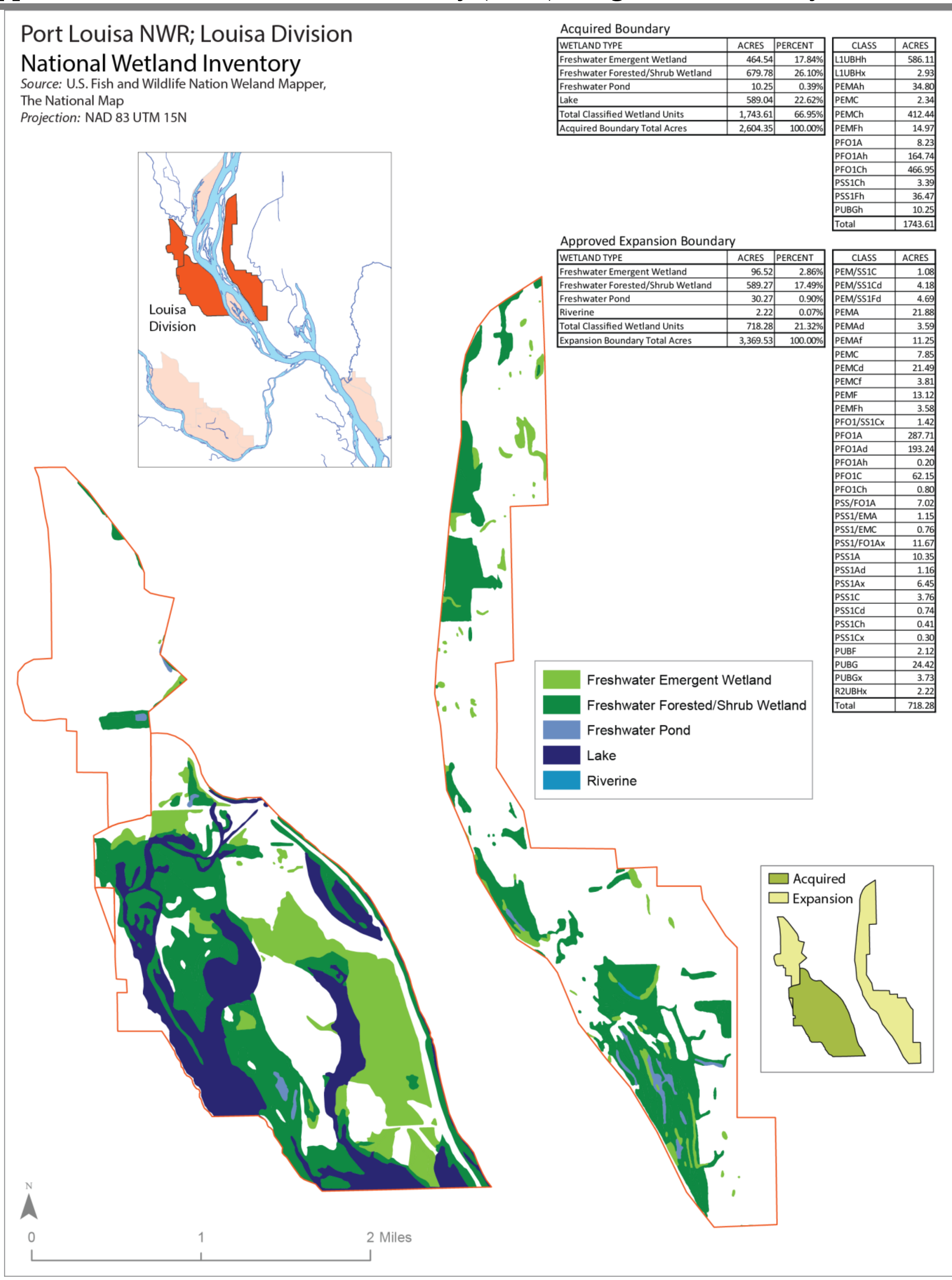


Figure 30 SSURGO soil database drainage classes for Keithsburg Division

13 Appendix D National Wetland Inventory (NWI) images and summary statistics



Acquired Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	464.54	17.84%
Freshwater Forested/Shrub Wetland	679.78	26.10%
Freshwater Pond	10.25	0.39%
Lake	589.04	22.62%
Total Classified Wetland Units	1,743.61	66.95%
Acquired Boundary Total Acres	2,604.35	100.00%

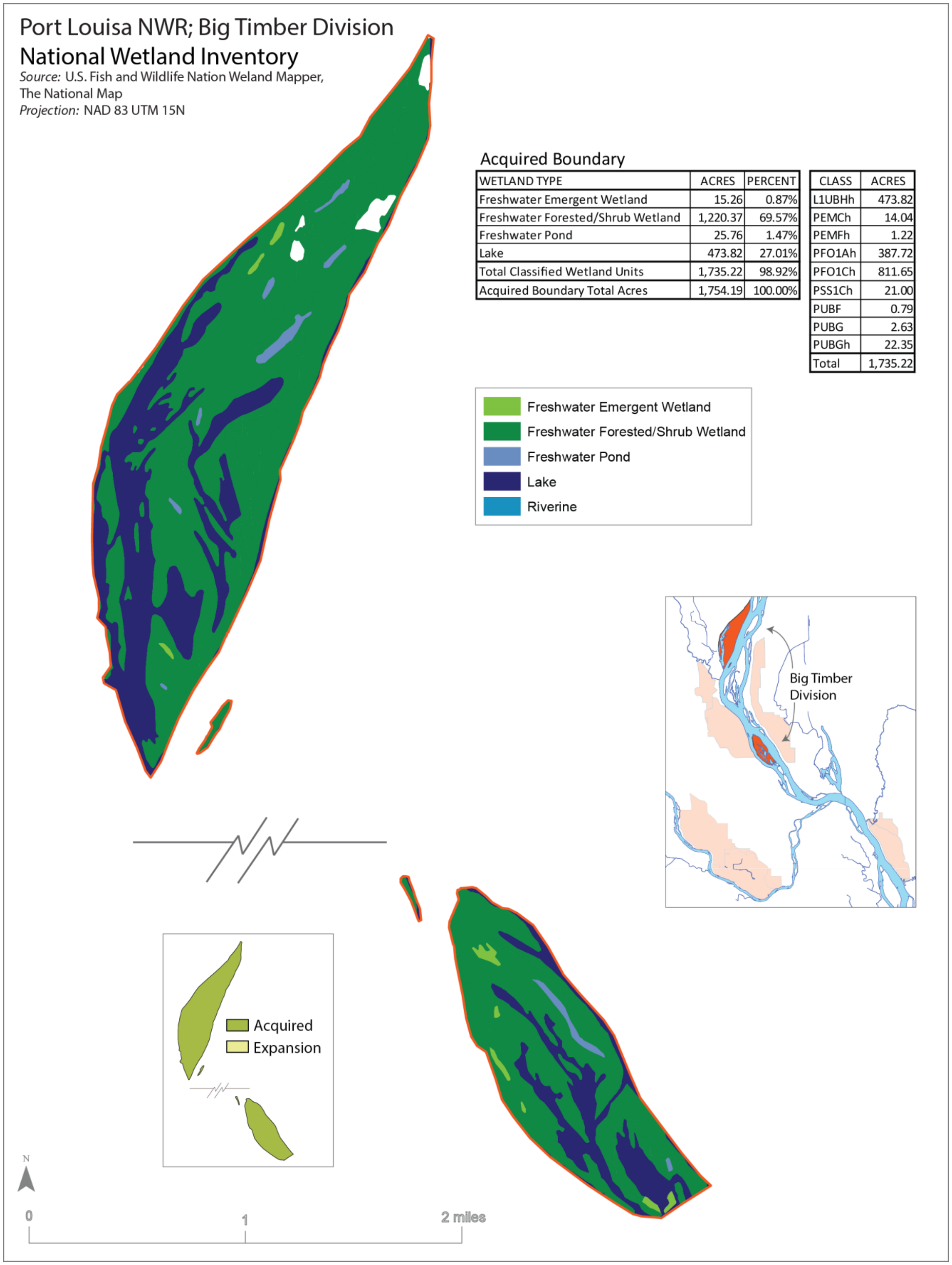
CLASS	ACRES
L1UBHh	586.11
L1UBHx	2.93
PEMAh	34.80
PEMC	2.34
PEMCh	412.44
PEMFh	14.97
PFO1A	8.23
PFO1Ah	164.74
PFO1Ch	466.95
PSS1Ch	3.39
PSS1Fh	36.47
PUBGh	10.25
Total	1743.61

Approved Expansion Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	96.52	2.86%
Freshwater Forested/Shrub Wetland	589.27	17.49%
Freshwater Pond	30.27	0.90%
Riverine	2.22	0.07%
Total Classified Wetland Units	718.28	21.32%
Expansion Boundary Total Acres	3,369.53	100.00%

CLASS	ACRES
PEM/SS1C	1.08
PEM/SS1Cd	4.18
PEM/SS1Fd	4.69
PEMA	21.88
PEMAd	3.59
PEMAf	11.25
PEMC	7.85
PEMCd	21.49
PEMCf	3.81
PEMF	13.12
PEMFh	3.58
PFO1/SS1Cx	1.42
PFO1A	287.71
PFO1Ad	193.24
PFO1Ah	0.20
PFO1C	62.15
PFO1Ch	0.80
PSS/FO1A	7.02
PSS1/EMA	1.15
PSS1/EMC	0.76
PSS1/FO1Ax	11.67
PSS1A	10.35
PSS1Ad	1.16
PSS1Ax	6.45
PSS1C	3.76
PSS1Cd	0.74
PSS1Ch	0.41
PSS1Cx	0.30
PUBF	2.12
PUBG	24.42
PUBGx	3.73
R2UBHx	2.22
Total	718.28

Figure 31 NWI map and statistics for Louisa Division

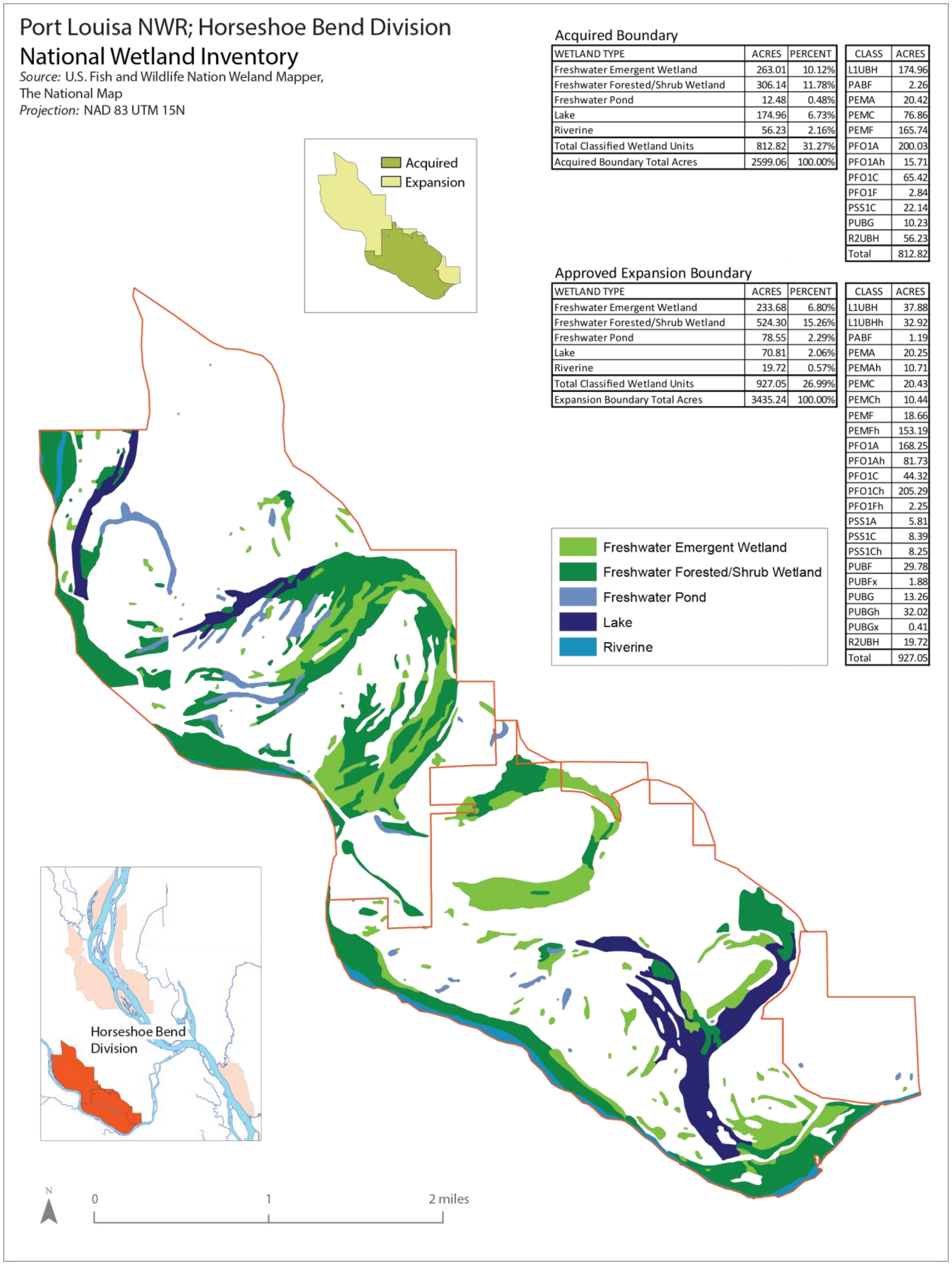


Acquired Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	15.26	0.87%
Freshwater Forested/Shrub Wetland	1,220.37	69.57%
Freshwater Pond	25.76	1.47%
Lake	473.82	27.01%
Total Classified Wetland Units	1,735.22	98.92%
Acquired Boundary Total Acres	1,754.19	100.00%

CLASS	ACRES
L1UBHh	473.82
PEMCh	14.04
PEMFh	1.22
PFO1Ah	387.72
PFO1Ch	811.65
PSS1Ch	21.00
PUBF	0.79
PUBG	2.63
PUBGh	22.35
Total	1,735.22

Figure 32 NWI map and statistics for Big Timber Division



Acquired Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	263.01	10.12%
Freshwater Forested/Shrub Wetland	306.14	11.78%
Freshwater Pond	12.48	0.48%
Lake	174.96	6.73%
Riverine	56.23	2.16%
Total Classified Wetland Units	812.82	31.27%
Acquired Boundary Total Acres	2599.06	100.00%

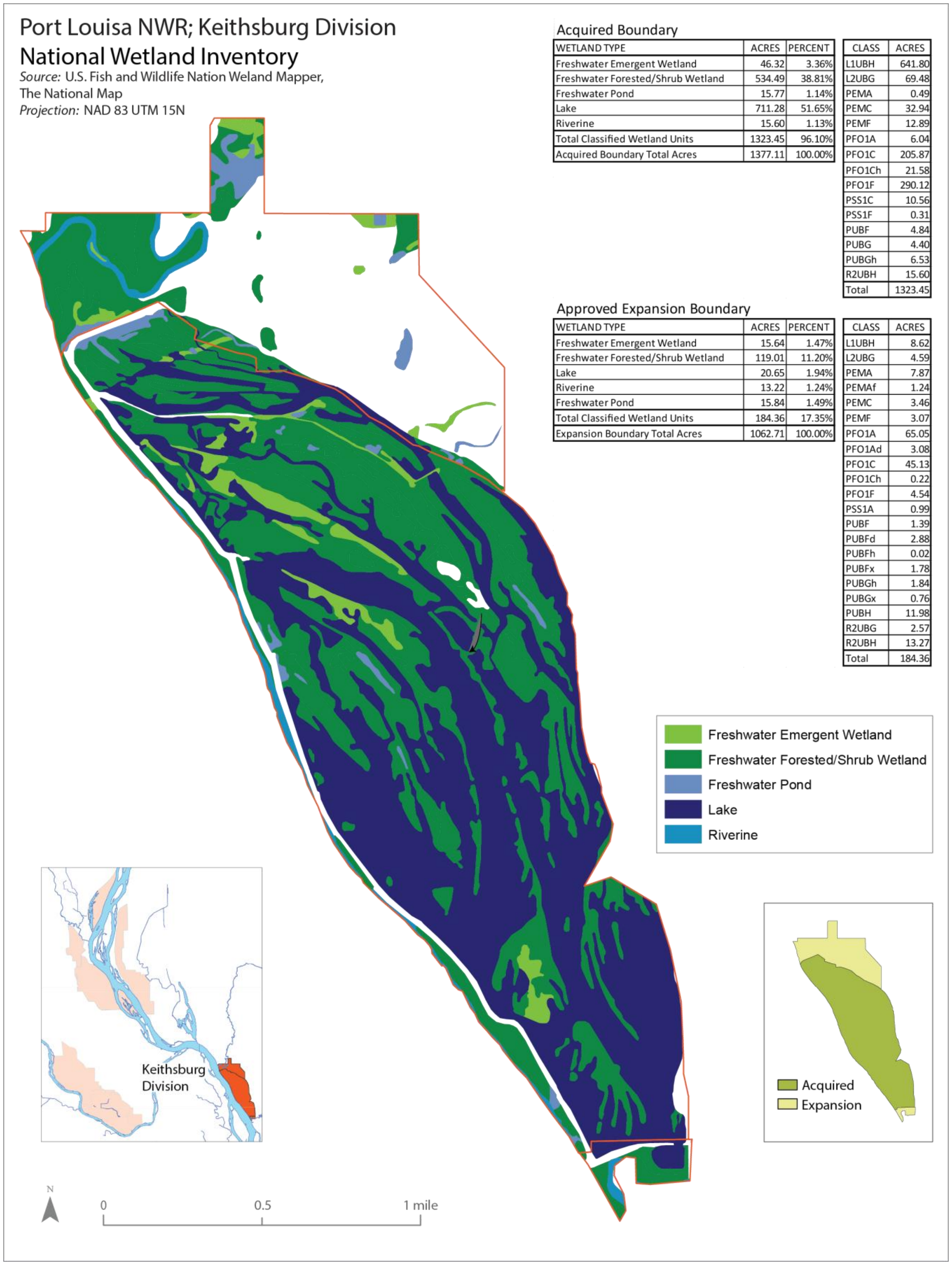
CLASS	ACRES
L1UBH	174.96
PABF	2.26
PEMA	20.42
PEMC	76.86
PEMF	165.74
PFO1A	200.03
PFO1Ah	15.71
PFO1C	65.42
PFO1F	2.84
PSS1C	22.14
PUBG	10.23
R2UBH	56.23
Total	812.82

Approved Expansion Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	233.68	6.80%
Freshwater Forested/Shrub Wetland	524.30	15.26%
Freshwater Pond	78.55	2.29%
Lake	70.81	2.06%
Riverine	19.72	0.57%
Total Classified Wetland Units	927.05	26.99%
Expansion Boundary Total Acres	3435.24	100.00%

CLASS	ACRES
L1UBH	37.88
L1UBHh	32.92
PABF	1.19
PEMA	20.25
PEMAh	10.71
PEMC	20.43
PEMCh	10.44
PEMF	18.66
PEMFh	153.19
PFO1A	168.25
PFO1Ah	81.73
PFO1C	44.32
PFO1Ch	205.29
PFO1Fh	2.25
PSS1A	5.81
PSS1C	8.39
PSS1Ch	8.25
PUBF	29.78
PUBFx	1.88
PUBG	13.26
PUBGh	32.02
PUBGx	0.41
R2UBH	19.72
Total	927.05

Figure 33 NWI map and statistics for Horseshoe Bend Division



Acquired Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	46.32	3.36%
Freshwater Forested/Shrub Wetland	534.49	38.81%
Freshwater Pond	15.77	1.14%
Lake	711.28	51.65%
Riverine	15.60	1.13%
Total Classified Wetland Units	1323.45	96.10%
Acquired Boundary Total Acres	1377.11	100.00%

CLASS	ACRES
L1UBH	641.80
L2UBG	69.48
PEMA	0.49
PEMC	32.94
PEMF	12.89
PFO1A	6.04
PFO1C	205.87
PFO1Ch	21.58
PFO1F	290.12
PSS1C	10.56
PSS1F	0.31
PUBF	4.84
PUBG	4.40
PUBGh	6.53
R2UBH	15.60
Total	1323.45

Approved Expansion Boundary

WETLAND TYPE	ACRES	PERCENT
Freshwater Emergent Wetland	15.64	1.47%
Freshwater Forested/Shrub Wetland	119.01	11.20%
Lake	20.65	1.94%
Riverine	13.22	1.24%
Freshwater Pond	15.84	1.49%
Total Classified Wetland Units	184.36	17.35%
Expansion Boundary Total Acres	1062.71	100.00%

CLASS	ACRES
L1UBH	8.62
L2UBG	4.59
PEMA	7.87
PEMAf	1.24
PEMC	3.46
PEMF	3.07
PFO1A	65.05
PFO1Ad	3.08
PFO1C	45.13
PFO1Ch	0.22
PFO1F	4.54
PSS1A	0.99
PUBF	1.39
PUBFd	2.88
PUBFh	0.02
PUBFx	1.78
PUBGh	1.84
PUBGx	0.76
PUBH	11.98
R2UBG	2.57
R2UBH	13.27
Total	184.36

Figure 34 NWI map and statistics for Keithsburg Division

14 Appendix E Most significant measured indicators of hydrologic alteration for the Edwards River at New Boston

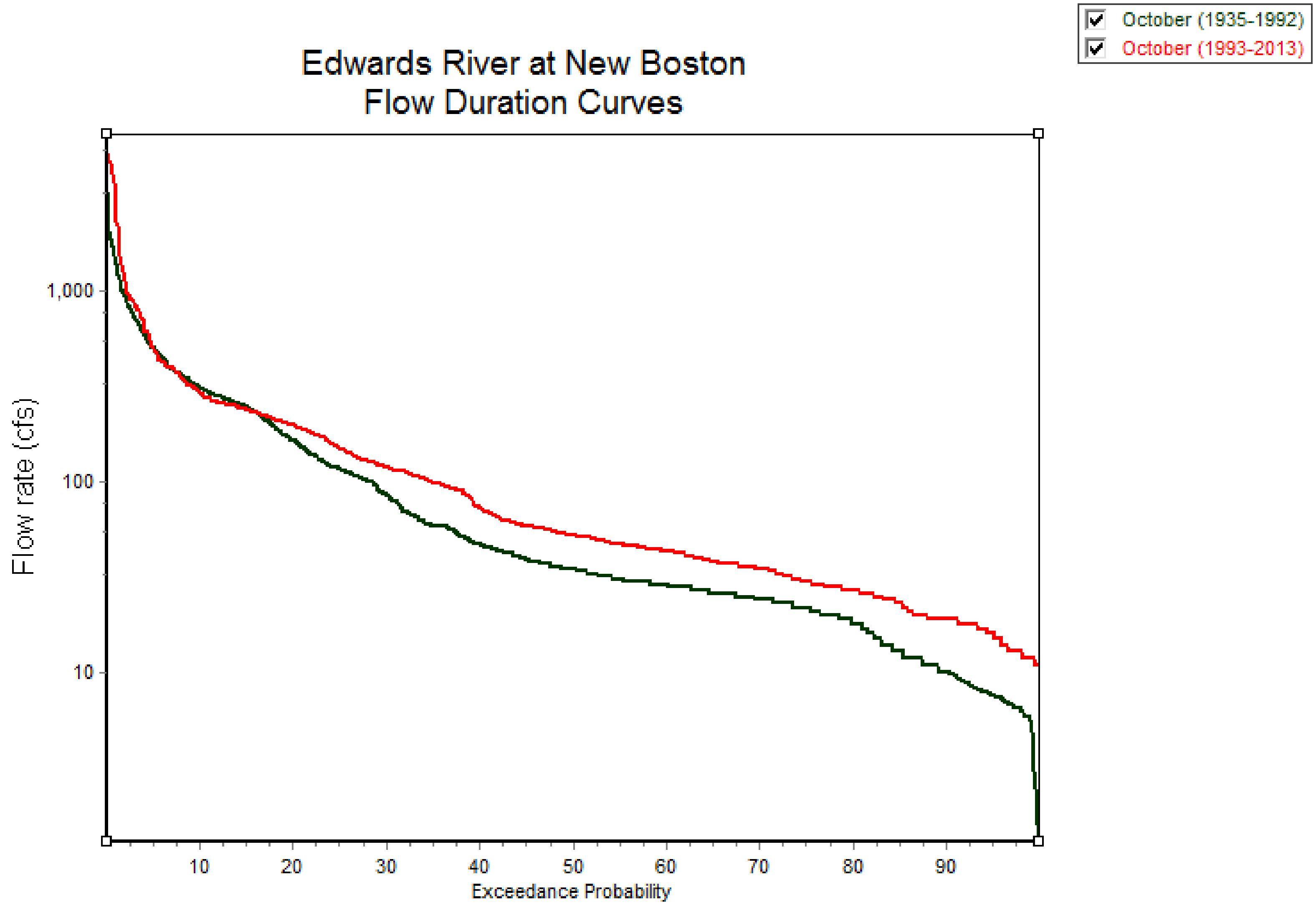


Figure 35 Probability of discharge exceeding specific flows for the Edwards River at New Boston

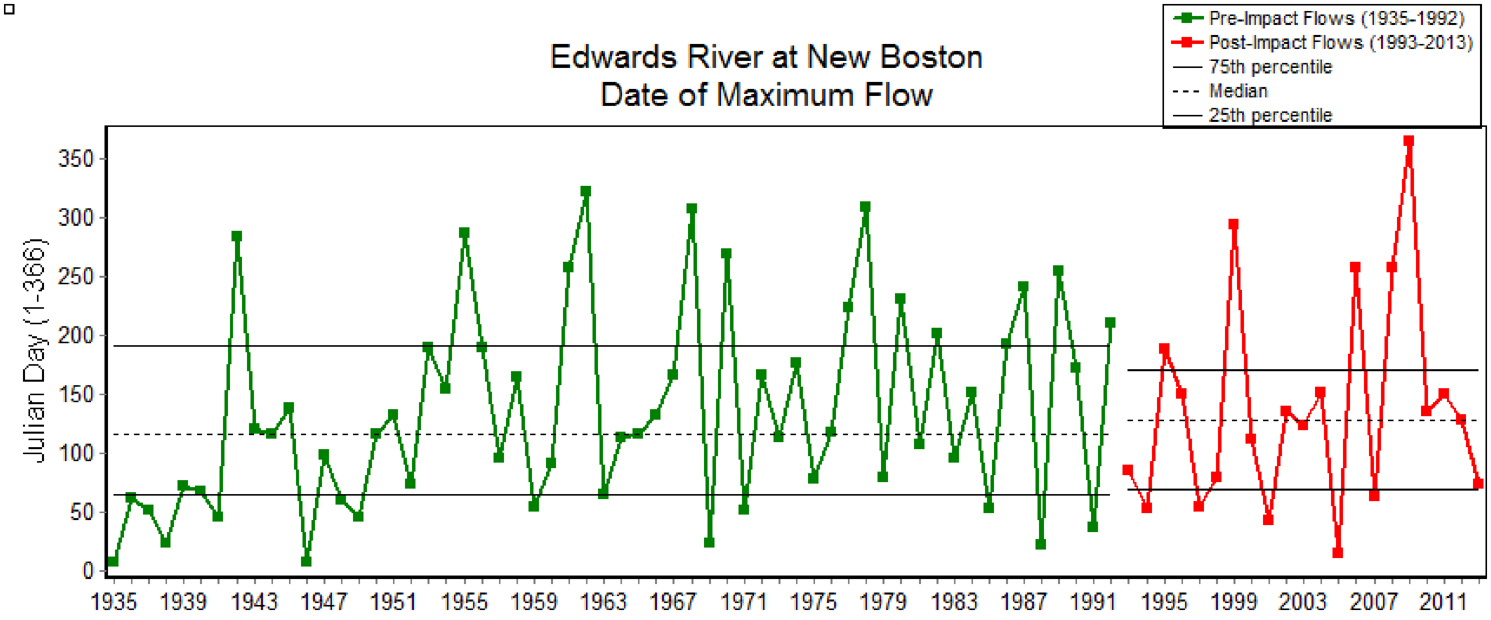


Figure 36 Date of maximum discharge for Edwards River at New Boston

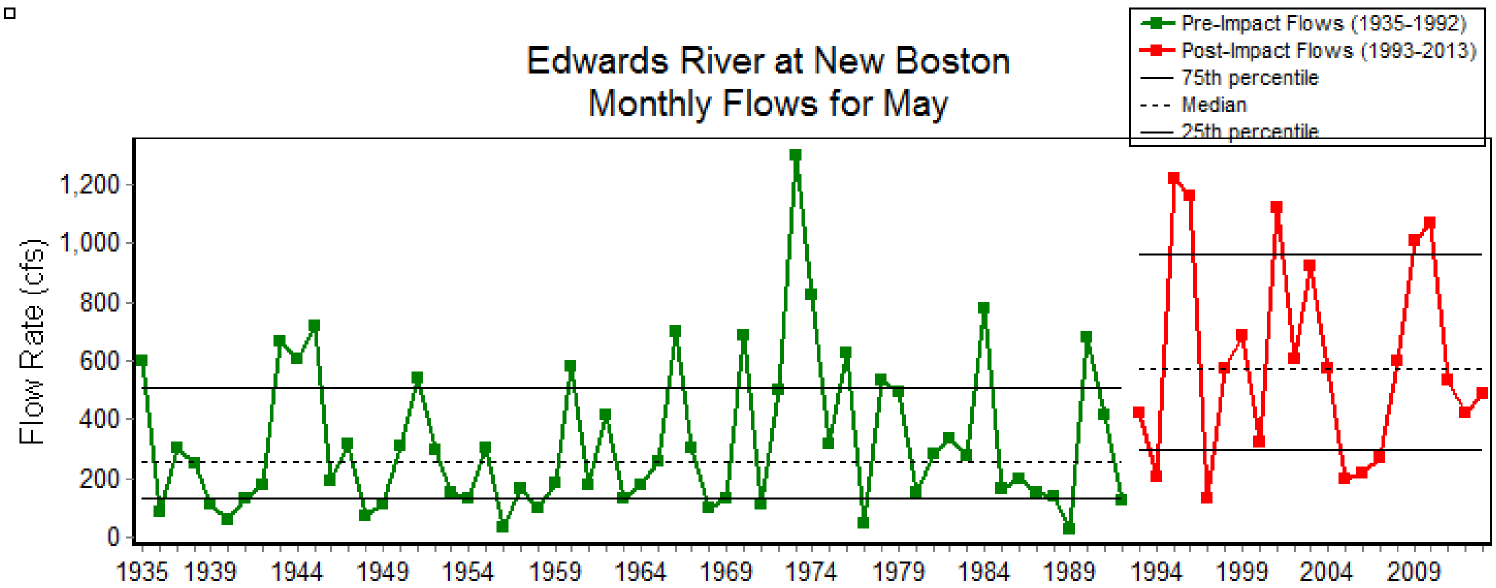


Figure 37 Monthly May discharge for Edwards River at New Boston

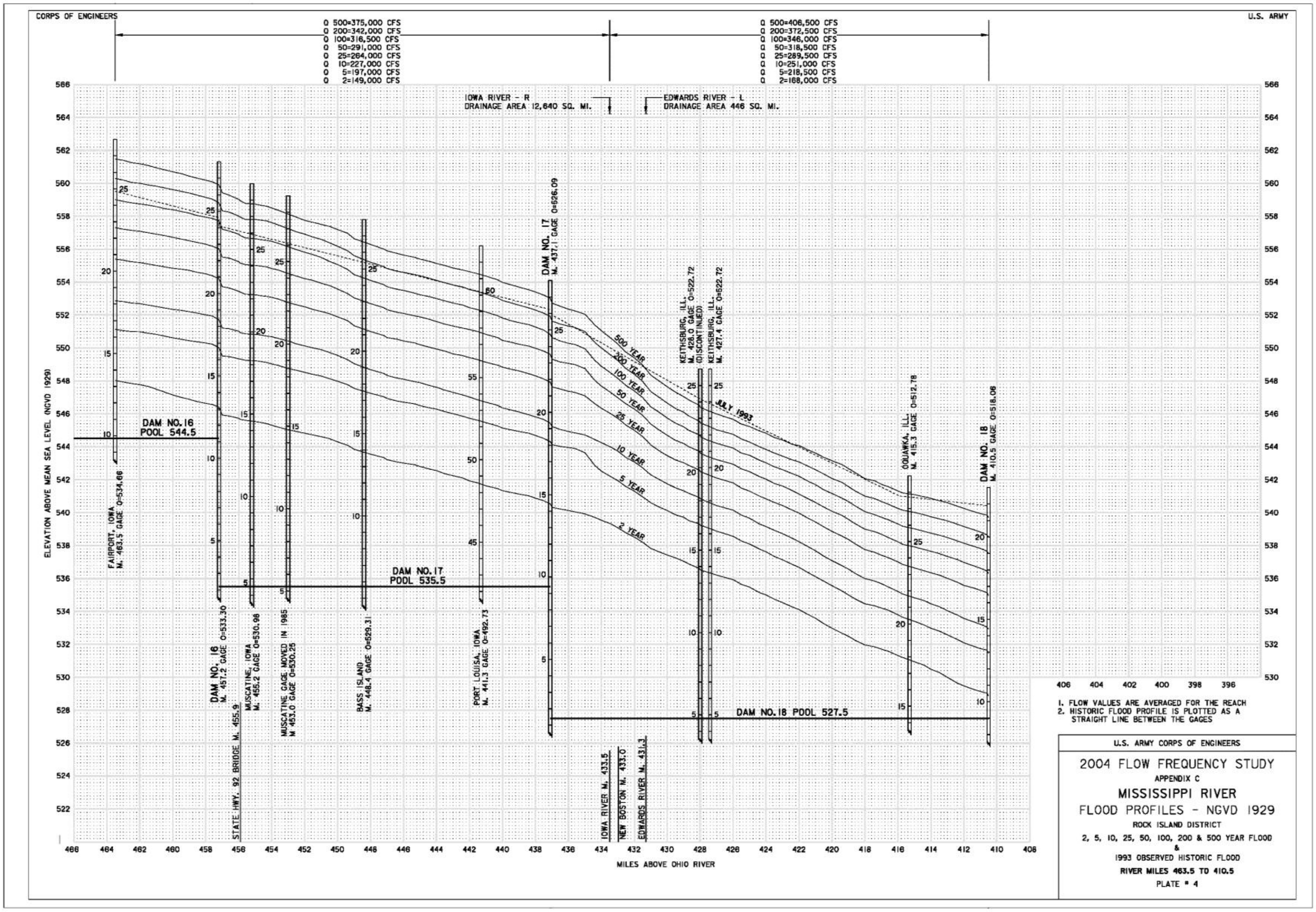


Figure 38 Mississippi River flood profiles (USACE 2004) for Divisions (river miles 463.5-410.5; NGVD 1929)